Queensland **the Smart State**

Developing indicators of recruitment and effective spawner stock levels in north Queensland east coast prawn stocks

Final Report Project No. 97/146

October 2005

Australian Government
Fisheries Research and Development Corporation

Queensland Government
Department of Primary Industries and Fisheries

Developing indicators of recruitment and effective spawner stock levels in north Queensland east coast prawn stocks

Final Report Project No. 97/146

October 2005

C. T. Turnbull, C. Shootingstar and S. Foster

ISBN 0 7345 0298 2
ISSN 0727 6281
QO04015

Developing indicators of recruitment and effective spawner stock levels in north Queensland east coast prawn stocks

C. T. Turnbull, C. Shootingstar and S. Foster
Department of Primary Industries and Fisheries, Queensland

October 2005

Project No. 97/146

Table of Contents

Figures

97/146
Developing indicators of recruitment and effective spawner stock levels in north Queensland east coast prawn stocks

PRINCIPAL INVESTIGATOR: Clive T. Turnbull
ADDRESS: Northern Fisheries Centre
Queensland Department of Primary Industries
PO Box 5396
Cairns QLD 4870
Telephone: 07 4035 0107 Fax: 07 4035 1401

OBJECTIVES:

1. To develop fishery-independent sampling procedures that can be used as robust long term methods for monitoring recruitment levels in the tiger and endeavour prawn fisheries located along the northern Queensland east coast and in Torres Strait.
2. To obtain a series of (fishery dependent) indices of spawner biomass and (fishery-independent) indices of recruitment that can be used to generate a long term data series.
3. Incorporation of the indices obtained in objective 2 into a stock-recruitment curve, an index of stock sustainability and an assessment of the risk of recruitment overfishing facing each of the species.

OUTCOMES ACHIEVED TO DATE

1. DPI&F has continued the annual surveys developed by the project as a component of the Fisheries Long Term Monitoring Program (LTMP). This was the main intent of the project and the reason for developing and testing the recruitment survey methodology.
2. The LTMP trawls surveys are providing species specific data on trends in the commercial prawns stocks along the northern Queensland east coast and in Torres Strait. This data enables DPI&F researchers and managers to monitor the status of individual stocks and ensure that stocks are being managed sustainably.
3. The data collected by the annual recruitment surveys has been used in recent stock assessments for tiger prawns in Torres Strait and along the northern Queensland east coast as a fishery-independent check on trends in the status of the stocks.
4. In addition to recruitment indices the LTMP surveys are providing data for the start of the season on bycatch and interactions with endangered and protected species.

Non-technical summary

In multi-species fisheries, such as the north Queensland east coast prawn trawl fishery, the individual species composition is not captured in the commercial harvest data (logbooks), as generally only the weight of catch in each of the main, catch categories (tiger, endeavour and king) are recorded. These catch categories consist of six main species, the brown tiger prawn (*Penaeus esculentus*), the grooved tiger prawn (*Penaeus semisulcatus*), the blue endeavour prawn (*Metapenaeus endeavouri*), the false or red endeavour (*Metapenaeus ensis*), the red spot king prawn (*Penaeus longistylus*) and the western or blue-leg king prawn (*Penaeus latisulcatus*). The distribution of these species varies with latitude and may also vary over time. To date only the commercial catch data and a relatively simple surplus production model have been used to assess the stocks of tiger and endeavour prawns in the northern section of the Queensland east coast prawn fishery. The model essentially treats the catch categories (tiger, endeavour, and king) as single species. The development of more complex delay-difference models, which incorporate biological parameters, necessitates partitioning of the commercial catch data into individual prawn species. This can only be achieved through the collection of information on the spatial and temporal distribution of these species on the north Queensland east coast. The northern LTMP prawn surveys partly address this need by providing species composition data for the start of each fishing season.

Although prawns are a short-lived species there is evidence of overfishing of tiger prawn fisheries in Western Australia (Penn et al., 1995) and more recently for brown tiger prawns in the Northern Prawn Fishery (NPF). The need for information from fishery-independent surveys to validate the results of the stock models based on the commercial harvest data was highlighted during a review of the NPF tiger prawn stock assessment by Dr Rick Deriso, an international stock assessment expert, and at Northern Prawn Fishery Assessment Group meetings during 2000–01. In his review, Dr Deriso also suggested using the fishery-independent surveys as an alternative method of tracking changes in the fishing power of the NPF fleet by comparing commercial catch rates over a number of years to the standardised survey catch rates.

Commercial catch rates, or Catch Per Unit of Effort (CPUE), which are used as an index of stock biomass, are biased by changes in the fishing power or efficiency of vessels and fishing gear (effort creep). Therefore downward trends in the catch rates obtained from commercial harvest data may be masked by increases in fishing efficiency. Standardised research trawl surveys provides alternative, fishery-independent CPUE indices that are not affected by 'effort creep'. In addition, a collection of fishery-independent data is recommended under the *Guidelines for ecologically sustainable management of fisheries* that Environment Australia have developed to implement the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The key objective of this study was to develop and test a robust and cost effective prawn recruitment survey methodology that could be adopted by the Department of Primary Industries and Fisheries (DPI&F) to monitor the status of the tiger and endeavour prawn stocks that are harvested along the north Queensland east coast and Torres Strait prawn fisheries. The survey methodology was developed and tested during the 1998 to 2000 surveys. In 2001, DPI&F incorporated the survey methodology into the Long Term Fisheries Monitoring Program (LTMP) that had been in operation for two years. The LTMP prawn recruitment surveys provide standardised catch rates of prawn abundance (numbers) and biomass (weight) by species at the start of the season. These catch rates provide a relative annual index of recruitment for the main tiger and endeavour prawn species. In addition, information is obtained on the size distribution of the main commercial prawn species that recruit into the fishery at the start of each fishing season. The data collected by the annual recruitment surveys is currently being utilised as a fishery-independent check on trends in the status of the tiger prawn stocks along the North Queensland east coast and Torres Strait.

The results presented in this report include the data from the 2001 and 2000 LTMP surveys that were conducted by DPI&F. This has enhanced the value of the final report by providing a longer time-series of data. The results show that fishery-independent recruitment surveys are a robust and cost effective tool for providing the data needed to monitor prawn stocks, especially in multi-species fisheries such as the northern Queensland east coast tiger prawn fishery. The recruitment indices provided by the surveys compared well with trends in the commercial harvest data, particularly for tiger prawns that are considered more susceptible to overfishing. The survey data complements the commercial harvest data and will assist with the development of species-based stock models for the north Queensland east coast tiger prawn fishery. The survey recruitment indices and the information on size structure of the stocks at the start of each fishing season provide a fishery-independent assessment of the status of the commercial prawn stocks at a species level.

KEYWORDS: tiger prawn, endeavour prawn, recruitment, fishery-independent surveys, spawner-stock

1 Background

The major aim of this study was to develop a fishery-independent recruitment survey methodology for the valuable tiger/endeavour prawn trawl fisheries that extends along the north Queensland east coast inside the Great Barrier Reef Lagoon and into Torres Strait. Prior to 1998 the status of these fisheries was monitored using only the commercial harvest data collected via compulsory fisher logbooks.

Although the species distribution of tiger and endeavour prawns extends along the entire Queensland east coast, targeted fishing for tiger and endeavour prawns is restricted to the northern section of the Queensland coastline. Williams (2002) defines the tiger and endeavour prawn 'sector' of the Queensland east coast trawl fishery as taking place largely in waters north of above 22˚S and has estimated a value of A$40m for this sector of the Queensland trawl fishery. Although the Torres Strait prawn fishery was originally an extension of the north Queensland fishery for tiger and endeavour prawns, since 1985 it been managed as a separate fishery under the Torres Strait Treaty between Australia and Papua New Guinea (Watson and Mellors, 1990). The value of the Torres Strait prawn fishery is estimated to be A$22m (McLoughlin, 2002).

Since 1992 the section of the Queensland east coast trawl fishery north of Cape Tribulation (16°S) and the Torres Strait prawn fishery have been subject to a seasonal closure during the months of December, January and February. The timing of the seasonal closure presents an ideal opportunity in late February to conduct fishery-independent recruitment surveys for these fisheries before the commencement of the commercial fishing season. Throughout this report the area of coastline encompassed by the seasonal closure (10.5˚S to 16˚S) is referred to as 'North Queensland'. Note that implementation of the new East Coast Trawl Management Plan in 1999 extended the seasonal closure to 22°S, which is between Mackay and Rockhampton.

The key objective of this study was to develop and test a robust and cost effective prawn recruitment survey methodology that could be adopted by the Department of Primary Industries and Fisheries (DPI&F) to monitor the status of the tiger and endeavour prawn stocks that are harvested in the North Queensland east coast and Torres Strait prawn fisheries. The survey methodology was developed and tested during the 1998 to 2000 surveys. In 2001 DPI&F incorporated the survey methodology into the Long Term Fisheries Monitoring Program (LTMP) that had been in operation for two years. The key objectives of the annual northern LTMP prawn surveys are:

- To monitor prawn species, size, distribution and relative abundance to contribute to assessments of the status of tiger, endeavour and king prawns in northern Queensland and Torres Strait waters; and
- To document bycatch in the fishery area to enhance our understanding of potential impacts of the fishery on the ecosystem.

The LTMP prawn recruitment surveys provide standardised catch rates of prawn abundance (numbers) and biomass (weight) by species at the start of the season. These catch rates provide a relative annual index of recruitment for the main tiger and endeavour prawn species. In addition, information is obtained on the size distribution of the main commercial prawn species that recruit into the fishery at the start of each fishing season. The data collected by the annual recruitment surveys has been used in recent stock assessments for tiger prawns in Torres Strait and along the northern Queensland east coast as a fishery-independent check on trends in the status of the stocks. Since 2001 the LTMP surveys have also been providing information on the distribution and abundance of byproduct and bycatch species.

Completion of project analyses and the final report were delayed, partly due to the continuation of the surveys under LTMP, which were an additional time commitment for the Principle Investigator. There were also initial difficulties in downloading the east coast trawl data from the CFISH database and re-constructing the data into a Microsoft Access database that could be used to identify and analyse the logbook records from the tiger prawn sector of the North Queensland trawl fishery. The Principle Investigator took advantage of this delay by negotiating with FRDC to include the data from the 2001 and 2002 LTMP surveys into the analysis presented in this report. This has enhanced the value of the final report by providing a longer time-series of data to compare with trends in the commercial harvest data.

2 Need

The 2nd World Fisheries Congress (1996) and concurrent Queensland Fisheries Management Authority (QFMA) workshop on ‘Sustainability Indicators’ highlighted the growing need for quantitative measures of the ‘sustainability’ of fisheries resources. In addition, the QFMA through the Management Advisory Committees identified development of monitoring programs to identify the size of parent stocks and recruitment levels as a high priority. The Monitoring Workshop convened by DPI&F in January 1998 identified tiger prawns as a species that should be monitored using research trawl surveys.

Although prawns are a short-lived species there is evidence of overfishing of tiger prawn fisheries in Western Australia (Penn et al. 1995) and more recently for brown tiger prawns in the Northern Prawn Fishery (McLoughlin, 2002). The need for information from fishery-independent surveys to validate the results of the stock models based on the commercial harvest data was highlighted during a review of the NPF tiger prawn stock assessment by Dr Rick Deriso, an international stock assessment expert, and at Northern Prawn Fishery Assessment Group meetings during 2000–01. In his review Dr Deriso also suggested using the fishery-independent surveys as an alternative method of tracking changes in the fishing power of the NPF fleet by comparing commercial catch rates over a number of years to the standardised survey catch rates.

Commercial catch rates or Catch Per Unit of Effort (CPUE), which are used as an index of stock biomass, are biased by changes in the fishing power or efficiency of vessels and fishing gear (effort creep). Therefore downward trends in the catch rates obtained from commercial harvest data may be masked by increases in fishing efficiency. Standardised research trawl surveys provides an alternative, fishery-independent, CPUE indices that are not affected by ‘effort creep’. In addition, collection of fishery-independent data is recommended under the *Guidelines for ecologically sustainable management of fisheries* that Environment Australia have developed to implement the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In multi-species fisheries, such as the northern Queensland east coast prawn trawl fishery, the individual species composition is not captured in the commercial harvest data (logbooks), as generally only the weight of catch in each of the main catch categories (tiger, endeavour and king) are recorded. These catch categories consist of six main species: the brown tiger prawn (*Penaeus esculentus*), the grooved tiger prawn (*Penaeus semisulcatus*), the blue endeavour prawn (*Metapenaeus endeavouri*), the false or red endeavour (*Metapenaeus ensis*), the red spot king prawn (*Penaeus longistylus*) and the western or blue-leg king prawn (*Penaeus latisulcatus*). The distribution of these species varies with latitude and may also vary over time. To date only the commercial catch data and a relatively simple surplus production model have been used to assess the stocks of tiger and endeavour prawns in the northern section of the Queensland east coast prawn fishery (Turnbull and Gribble, 2003). This model essentially treats the catch categories (tiger endeavour, and king) as single species. The development of more complex delay-difference models, which incorporate biological parameters, necessitates partitioning of the commercial catch data into individual prawn species. This can only be achieved through the collection of information on the spatial and temporal distribution of these species on the northern Queensland east coast. The northern LTMP prawn surveys partly address this need by providing species composition data for the start of each fishing season.

3 Objectives

1. To develop fishery-independent sampling procedures that can be used as robust long term methods for monitoring recruitment levels in the tiger and endeavour prawn fisheries located along the northern Queensland east coast and in Torres Strait.
2. To obtain a series of (fishery-dependent) indices of spawner biomass and (fishery-independent) indices of recruitment that can be used to generate a long term data series.
3. Incorporation of the indices obtained in objective 2 into a stock-recruitment curve, an index of stock sustainability and an assessment of the risk of recruitment overfishing facing each of the species.

4 Methods

The major component of this project was the design and testing of a standardised research survey that could used be to monitor the status of tiger and endeavour prawn stocks by providing fishery-independent estimates of recruitment. The trends in the survey results were compared with trends in the commercial harvest data to test the effectiveness of the surveys as a means of monitoring the stocks of tiger and endeavour prawns (objectives 1 and 2). A second, but minor, component of the project was to calculate a spawning stock index based on commercial harvest data (objective 2) and start investigating stock recruitment relationships (objective 3) based on the results of objective 2. Objective three was only partially addressed in the study, as the five surveys analysed in this report are a short time-series on which to estimate stock-recruitment relationships. Objective 3 identifies some important results that may eventually flow from the annual LTMP northern trawl surveys.

4.1 Recruitment surveys

4.1.1 Survey design

The surveys are conducted just prior to the opening of the northern Queensland and Torres Strait prawn trawl seasons to provide fishery-independent information on size and abundance of prawns by species and gender, that are available to the fleet at the start of each fishing season (recruits to the fishery). The design of the recruitment surveys attempts to standardise the catch rates between surveys (years) by using, where possible: the same fixed sites, vessel, trawl nets, time of the season and lunar phase for each survey. This strategy aims to ensure that variations in survey catch rates between years reflect annual variation in the recruitment to the fishery.

The survey design was based on monthly surveys conducted during earlier studies by Turnbull and Watson (1991) and Derbyshire et al. (1995). The same vessel, nets and a sub-set of the sites used in these earlier studies were incorporated into the recruitment survey design for this study. This enabled comparison of the current survey results with these earlier studies.

4.1.2 Timing

The timing of the annual recruitment surveys is a compromise between spanning the period of the new moon and conducting the surveys as close as possible to the start of the fishing season (1 March). Analysis of commercial catch rates data for tiger and endeavour prawns indicates a small interaction between catch rates and moon phase. Therefore, the surveys are planned where possible to coincide with the February new moon. Several of the surveys, however, were delayed due to bad weather (cyclones) or vessel breakdowns. Sampling prior to early February is also avoided as many of the prawn recruits to the fishery may still be in shallow inshore areas that are inaccessible to the research trawler. If necessary, adjustments can be made to the survey catch rates to compensate for the effects of moon phase.

Table 1 details the recruitment surveys that were conducted during 1998 to 2002. The first three northern surveys (Cape Flattery to Torres Strait, 1998, 1999 and 2000) were a major component of this project. Queensland DPI&F Long Term Monitoring Program funded the 2001 and 2002 northern surveys and the data was included in the analysis for this report. In 2002, a survey was also conducted on the commercially important fishing grounds between Townsville and Cairns using funding from the CRC Reef project *Coastal Fisheries Resource Monitoring in the Great Barrier Reef World Heritage Area* (Hyland 2003). Due to logistics, this region south of Cairns was surveyed over the second new moon after the start of the season during 2002. There were some delays experienced in 1999 and 2000 due to cyclones along the north Queensland coast.

Table 1 Timing of annual prawn surveys completed between 1998 and 2002.

Year	**Survey region**	**Start date**	**End date**	**Date of new moon**
1998	Cape Flattery to Torres Strait	17/02/1998	02/03/1998	26/02/1998
1999	Cape Flattery to Torres Strait	15/02/1999	01/03/1999	15/02/1999
2000	Cape Flattery to Torres Strait	23/02/2000	07/03/2000	05/03/2000
2001	Cape Flattery to Torres Strait	20/02/2001	05/03/2001	22/02/2001
2002	Cape Flattery to Torres Strait	05/03/2002	20/03/2002	12/03/2002
2002	Townsville to Cairns	11/04/2002	17/04/2002	12/04/2002

4.1.3 Location and stratification of the survey sites

During the first survey in February of 1998 the vessel's Global Position System (GPS) was used to established fixed one nautical mile sites between Cape Flattery (15°S) and PNG waters in Torres Strait (9.5°S). This strategy helped to standardise the survey results between years by removing the variation that would be introduced by randomly varying the site positions within the strata during consecutive surveys. The main objective is to monitor relative changes in stock abundance between years. A very intensive sampling strategy would be required to estimate absolute stock biomass. This would be expensive and logistically difficult to achieve over such a large geographic range.

4.1.3.1 North Queensland

The North Queensland trawl fishery for tiger and endeavour prawns is located in the relatively narrow corridor formed by the inshore coastal lagoon of the Great Barrier Reef (GBR). The Great Barrier Reef Marine Park Zoning further restricts commercial trawl fishing to the 'General Use' zone (Figure 1).

Due to the wide geographic range covered by the fishery, the North Queensland coast was stratified (Table 2) into areas that reflect changes in the commercial fishery effort and catch. The highest numbers of sites (Figure 1) were established in the 30-minute CFISH grids that encompass the Princess Charlotte Bay and Cape Flattery areas of the fishery. These areas are the most heavily fished within the North Queensland trawl fishery and also produce the highest tiger and endeavour prawn catches (Figure 2 and Figure 3). In addition there is some king prawn catch associated with the fishing targeted on tiger prawns (Figure 3).

The stratification and location of sites within the strata was designed to obtain the highest survey catch rates and reduce sample variance. This was achieved by locating sites over a range of depths in areas that were known to be frequently fished by the commercial vessels. Research data for the North Queensland (Derbyshire et al. 1995) and Torres Strait (Blyth et al. 1990) prawn fisheries indicates that recruitment consists of a range of age cohorts and that the timing of the migration of the strongest cohort into the fishery can vary between years. As tiger prawns generally move from shallow inshore waters into deeper offshore waters as they age and grow the recruitment to the fishery at the start of the season may be spread over a range of depths.

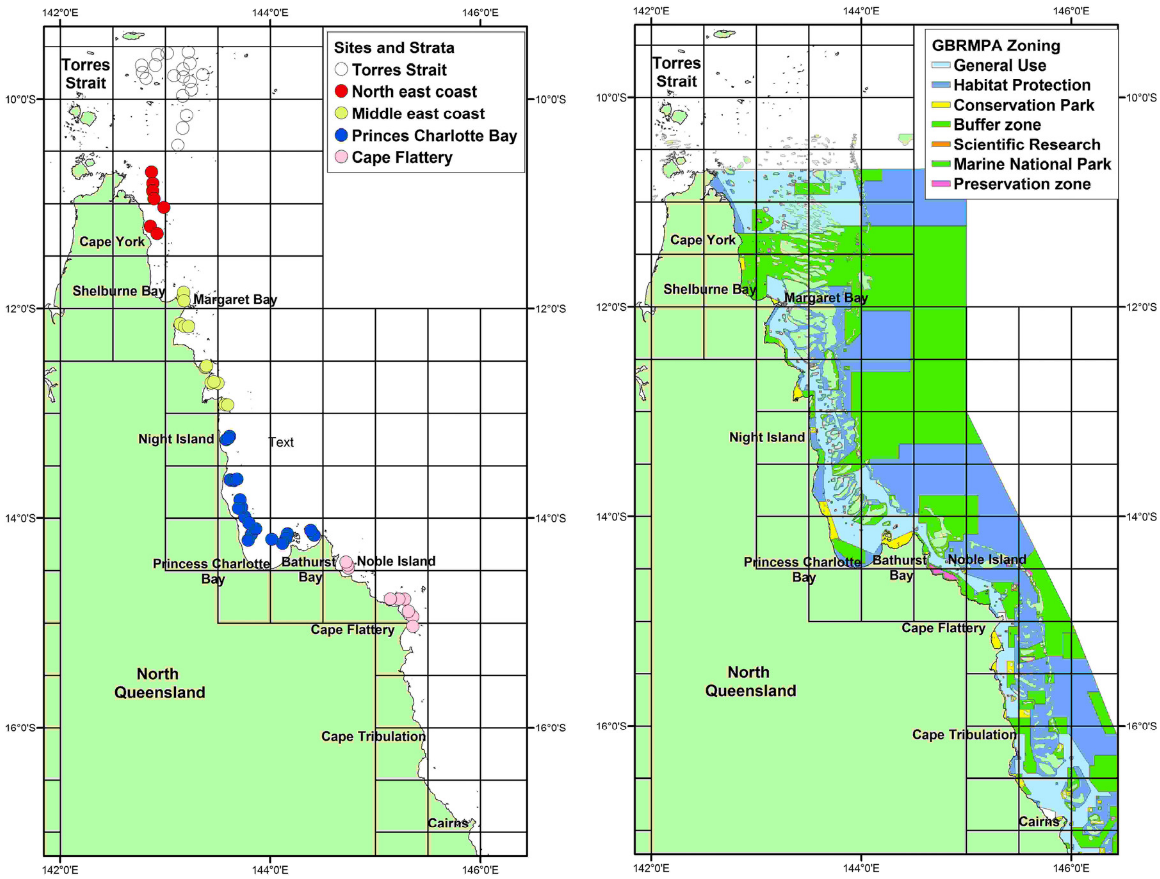

Figure 1 North Queensland survey sites (left) and GBMRPA Zoning (right).

All of the sites just to the north of Cape Flattery are a sub-set of the sites that were sampled each month by Derbyshire et al. (1995). The location of survey sites within Bathurst Bay and Princes Charlotte Bay was based on information from a monthly survey program conducted during 1990–91 (Derbyshire et al. 1992). This study used a chartered commercial vessel to randomly sample various depth grids each month within Bathurst Bay and Princes Charlotte Bay. The depth grids that provided the best information on recruitment were chosen to represent these areas and random fixed sites allocated within the chosen depth grids. The strategy of using the same sites where possible as those used in earlier studies makes it easier to compare the current survey results with the earlier studies.

Table 2 Stratification of the North Queensland survey sites.

Strata name	Number of sites	30–minute CFISH grid reference	Description of strata
North East Coast	7	B4, B5, C4, C5	Tip of Cape York to the Northern edge of the Shelburne Bay GBRMPA ‘Green Zone’.
Middle East Coast	14	C6, C7, C8, D8	Margaret Bay to north of Night Island.
Princess Charlotte Bay	21	D9, D10, D11, E11	Night Island to Bathurst Bay. This is the most heavily fished and productive section of the Queensland east coast tiger prawn fishery.
Cape Flattery	9	F11, G12,G13	Noble Island to Cape Flattery. This is the second most productive and intensively fished section of the fishery.

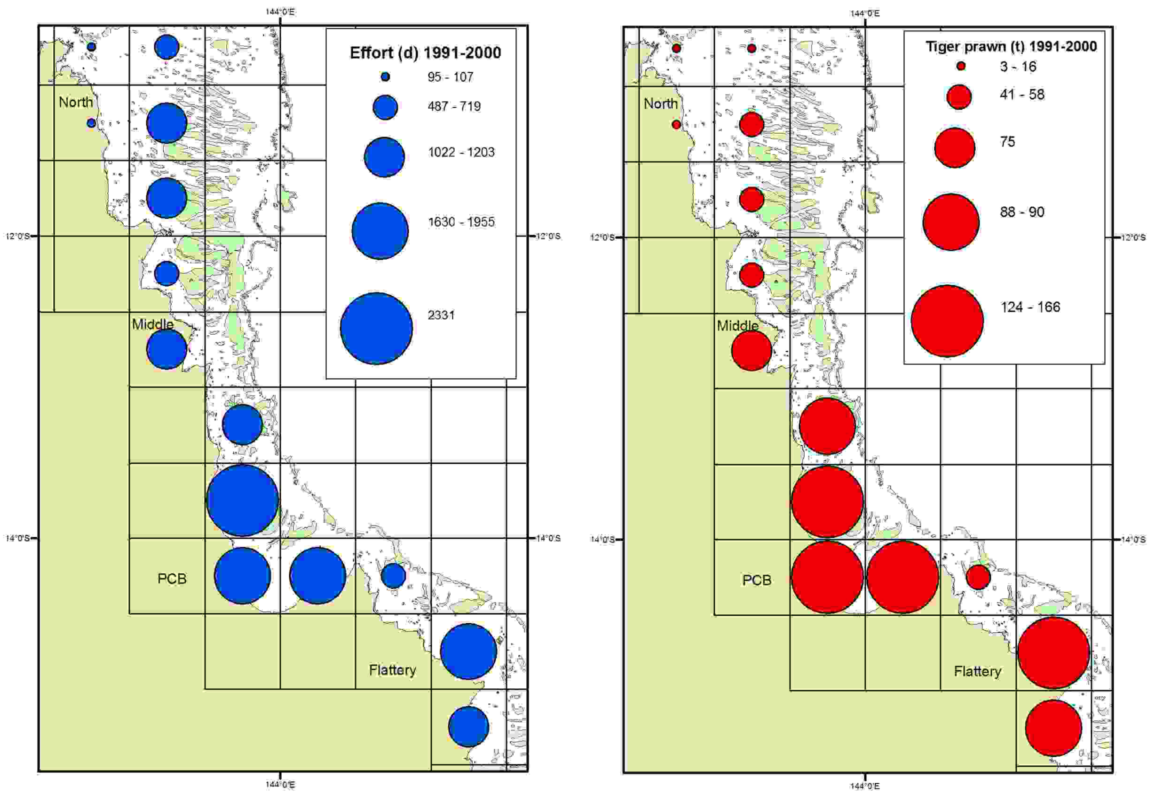

Figure 2 Distribution of average annual fishing effort (days) for the years 1991-2000 by 30-minute CFISH grids (left) and average annual tiger prawn catch (t) by 30-minute CFISH grid (right).

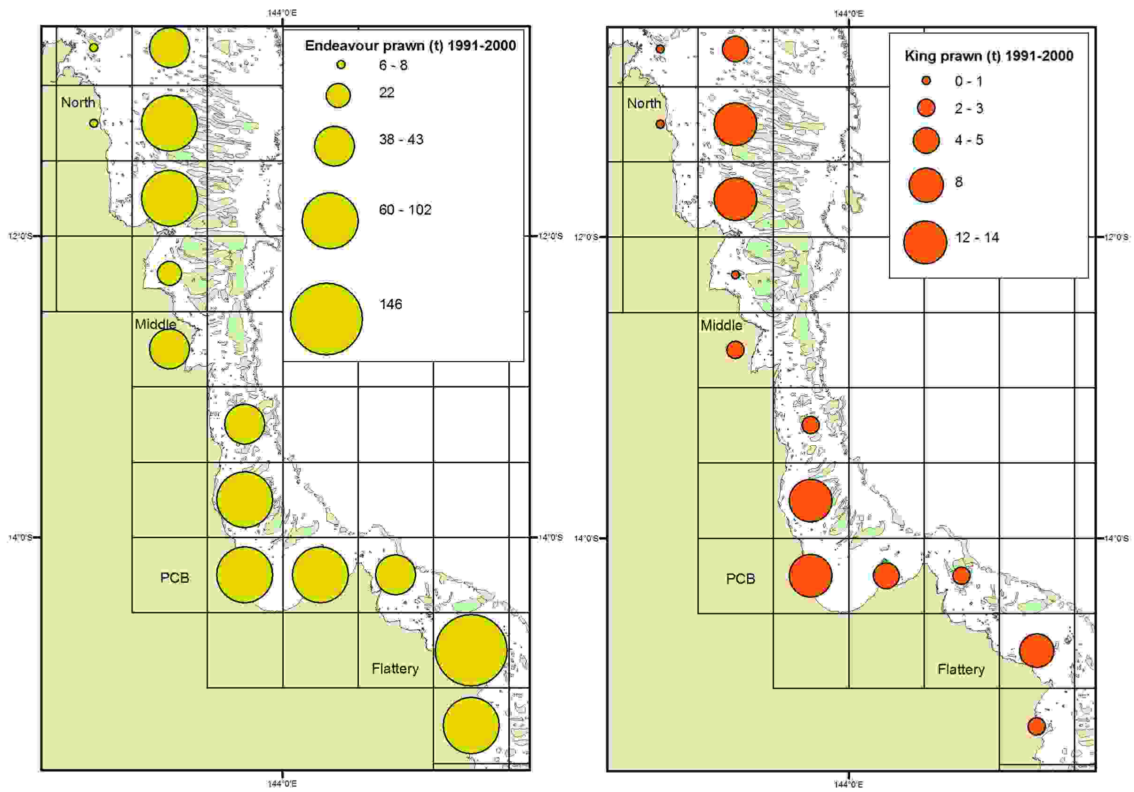

Figure 3 Distribution of average annual endeavour (left) and average annual king prawn catch (right) for the years 1991–2000 by 30-minute CFISH grids.

4.1.3.2 Torres Strait

The Torres Strait Prawn Fishery is regarded as harvesting a separate stock of tiger and endeavour prawns from the North Queensland east coast trawl fishery. The location (Figure 4) and stratification (Table 3) of the Torres Strait fishery is based on the known biology of the commercial prawn stock in Torres Strait (Blyth et al. 1990, Turnbull and Watson, 1991) and the current spatial/temporal closure arrangements for the fishery. The monthly research trawl surveys and prawn tagging conducted by Queensland Department of Primary Industries (QDPI) during 1985–1991 indicated that brown tiger prawns move off the seagrass nurseries on Warrior Reef into the shallow silty waters to the west of the reef at a very small size, then grow and migrate from the closed area west of Warrior Reef, eastward into the fishery (Turnbull, 1991).

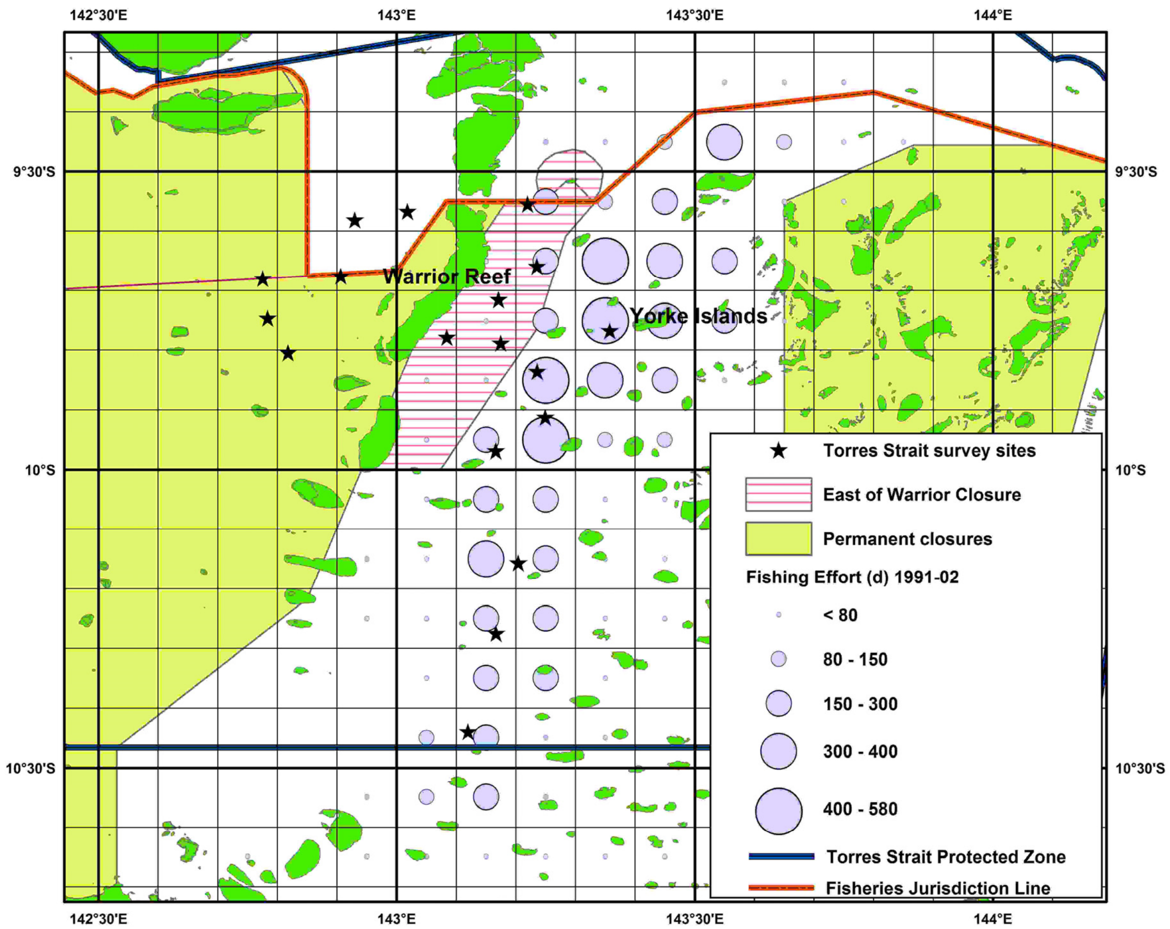

Figure 4 Torres Strait surveys sites. Note that two sites are within Torres Strait waters that are under Papua New Guinea jurisdiction. The average annual fishing effort by six-minute grid for the years 1991–2002 indicates the main area in which Australian trawlers operate.

In 1980 the area to the west of Warrior Reef was permanently closed at the request of industry as they believed it to be the nursery grounds for the fishery. In 1991 the 'East of Warrior Closure' was introduced on the basis of QDPI research data and at the request of industry. This 10 nautical mile wide spatial/temporal closure along the eastern side of Warrior Reef (Figure 4) is designed to prevent 'growth-overfishing' during the early part of the fishing season. The area is only open to fishing for four months at the end of the season. The monthly research surveys conducted by Turnbull and Watson in 1991 indicate that prawns migrate from the closure into the fishery during March to June and that the closure reduces growth-overfishing on endeavour prawns in particular.

Table 3 Stratification of the Torres Strait survey sites.

Strata name	Number of sites	Description of strata
Fishery	7	Area open to fishing from 1 March to 30 November.
East of Warrior Closure	5	Area open to fishing from the 1 August to 30 November.
West	6	Permanently closed area west of Warrior Reef.

A sub-set of the sites sampled on a monthly basis during the 1986–91 by the QDPI Torres Strait Prawn Project was chosen for the current recruitment surveys. In addition the current study used the same research vessel and design of nets as those used by the Torres Strait Prawn Project during 1990–91 therefore we are able to easily compare current survey results with the earlier study.

4.1.4 Trawl sampling procedure and nets

The recruitment surveys of Queensland's northern prawn populations were conducted using the Department's 18-metre research trawler *Gwendoline May*. A quad gear configuration consisting of 4 by 4 fathom nets was used to trawl one nautical mile at each sample site. Two of the nets were constructed of a fine mesh (32mm mesh knot to knot — this is below legal size for commercial nets) to maximise the catches of sub-adult prawns. The other two nets were of commercial mesh size (51mm mesh) to provide the data needed to estimate the proportion of the two tiger prawn and endeavour prawn species in the commercial catch at the start of the season. The outer net on each side of the vessel were the fine mesh nets. This gear configuration is essentially the same as that used by the QDPI Torres Strait Prawn Project during 1990–91 and by Derbyshire et. al (1995). This was done to allow comparison of the current survey results with the results of the earlier studies.

4.1.5 Sample processing

Most of the samples from the first two surveys were frozen and returned to laboratory for processing. The species, sex, carapace length, ovary condition, insemination and moult condition of each prawn were recorded. The individual weights of animals from a subset of the samples were also recorded to estimate the length-weight relationship parameters for the six main commercial species. Some of the smaller samples were processed onboard the vessel.

During the final FRDC survey, February 2000, the data recording protocol was simplified by dropping the recording of ovary condition, insemination and moult condition. In addition carapace length was recorded to the nearest millimetre instead of 0.1 mm. These changes, combined with an audio data recording system, allowed most samples (11 000 to 30 000 prawns per survey) to be processed onboard the vessel and also speeded up the data entry process.

A procedure for rapidly recording the species, gender and carapace length of large numbers of prawns was developed by the principal investigator during observer studies on Torres Strait commercial vessels during 1993–94. This system was utilised and further developed as part of this study. A micro-cassette tape recorder and a small tie clip microphone held in the researchers ear by a custom-made ear fitting, is used to record the researchers voice. External noise is reduced using standard noise reduction earmuffs. The tape recorder's earpiece is placed in the opposite ear to permit checking of the recording process. This system allows one researcher to rapidly record a large number of prawn measurements. The prawns are arranged into species and gender prior to measuring and a standardised recording protocol used to maximise the speed and accuracy of the recording process. During data entry the tapes are usually replayed using fast playback, which provides a good data entry speed. The tapes are replayed a second time to validate the data entry process. This system has proved very efficient and reliable. The option of using voice recognition software to download the data from the tapes directly into an Excel spreadsheet is currently being investigated.

The option of using electronic callipers to expedite the measuring and recording process was also investigated. Unfortunately, none of the electronic digital callipers currently on the market are reliable in a marine environment. Limnoterragroup Services (www.limnoterragroup.com), a Canadian company that manufactures electronic fish measuring boards, did have a digital electronic calliper on the market for a short time. Unfortunately, this model was withdrawn due to technical problems and is still not available although it is still advertised on their website as 'temporarily on hold pending redesign'.

4.2 Analysis of commercial harvest data

The main reasons for analysing Torres Strait and northern Queensland east coast commercial harvest data were to:

1. Check whether the survey recruitment indices are a reliable index of recruitment by investigating the extent to which they match with and explain the trends in commercial catches and catch rates.
2. Estimate (fishery dependent) indices of spawner biomass that could be used with the survey recruitment indices to investigate stock recruitment relationships.

The commercial data for North Queensland was stratified in the same way as the survey data. It was not appropriate to stratify the Torres Strait commercial data using the same stratification as most of the survey sites are in closed or partially closed waters.

4.2.1 Data sources

The recruitment surveys cover both the northern section of the Queensland east coast trawl fishery, which is managed by the Queensland Department of Primary Industries and Fisheries (DPI&F), and the Torres Strait prawn fishery, which is jointly managed by the Commonwealth Australian Fisheries Management Authority (AFMA) and the State DPI&F. There are separate logbook systems for each fishery. The commercial harvest data for the Torres Strait prawn fishery is collected by AFMA as a component of the Northern Prawn Fishery logbook system, while the logbook data for the Queensland east coast trawl fishery is collected by DPI&F.

AFMA regularly provides DPI&F research staff based at Northern Fisheries Centre (NFC) with downloads of the Torres Strait prawn logbook data. These downloads are used to update a Microsoft Access database of Torres Strait prawn fishery data that is maintained at NFC. At the end of each season this database is used to analyse trends in catch and effort and the results are published in annual editions of the Torres Prawn Handbook (Kung et al. 2005), which is distributed to all Torres Strait fishers.

SQL scripts were developed to download northern Queensland east coast commercial trawl data from the CFISH database. The data was then loaded into a Microsoft Access database (similar to the Torres Strait database) to analyse spatial and temporal trends in catch, effort and catch rates.

4.2.2 Data filters

As the Queensland east tiger prawn fishery is a multi-species fishery it was necessary to filter out records that are probably associated with targeting of other species such as banana or red spot king prawns. The distributions of these species largely overlap with the distribution of tiger and endeavour prawns and much of the position information is fairly course (30-minute or 6-minute grid level); therefore, they cannot be separated using the spatial information in the CFISH database. The daily vessel catch composition was, therefore, used to establish which species were being targeted for each daily vessel catch record.

The following filters were applied to the data to calculate 'targeted' catch and effort for tiger prawns. These are the same as those used to produce the input data for the current east coast tiger and endeavour prawn stock assessments (Turnbull and Gribble, 2003):

- Records that were not bulk data, which represent more than one day's catch and effort.
- Proportion of tiger prawn in the daily vessel catch >10%.
- Proportion of banana prawn in the daily vessel catch <50%.
- Proportion of king prawn in the daily vessel catch <50%.
- The same rules, but with proportion of endeavour prawn >10% instead of proportion of tiger prawn was used to calculate 'targeted' catch and effort for endeavour prawns.

A flag (Pday), which is based on the number of hours trawled per day, was also used to eliminate daily vessel records that represented only a part night of fishing or fishing into daylight hours. The 'normal night of trawling' restriction was applied in addition to the above rules when calculating CPUE-based indices such as the spawner index and commercial recruitment indices.

4.2.3 Indices of spawner biomass

The available biological research information on the spawning behaviour of tiger prawns in Torres Strait and on the North Queensland east coast was used to determine the combination of fishing grids and months that could be used to estimate an index of spawner biomass from the commercial harvest data.

4.3 Analysis of survey data

4.3.1 Prawn length-weight relationships

Although estimates of length-weight relationships already existed for some of the commercial prawn species they were based on samples from a limited geographic range. The recruitment surveys provided an opportunity to estimate the length-weight relationships for all six species from samples that covered the entire geographic range from Cape Flattery (15°S) to Torres Strait (9°S).

Carapace Length to the nearest 0.1 mm and wet weight to nearest 0.1 gm was recorded for a large representative sample of each of the 6 main commercial species. The entire range of sizes was included in the sample and where possible approximately equal numbers from various size ranges.

Both the standard two-parameter model ($W = aL^b$) and a more general three-parameter model ($W = k + aL^b$) that allows a non-zero intercept (k) were fitted to the data for each species and gender. The models were fitted using both Microsoft Excel and GenStat Release 6.1. The GenStat software provides the standard error of the estimates and percentage variance accounted for by the models. The two-parameter model was used to estimate the individual weight of each prawn in the database. All of the weight-based estimates provided in the report are based on carapace length converted to prawn weight.

4.3.2 Species and gender composition, size distribution and catch rates

A general analysis of the species composition, size frequency distribution and catch rates of the survey data is contained in (Turnbull et al. 2004). An electronic copy of this report titled *Fisheries Long Term Monitoring Program: A Summary of Tiger and Endeavour Prawn Survey Results: 1998–2002*, included on the CD enclosed in the back cover of this report.

As the two reports were written concurrently it was considered more appropriate to include the LTMP prawn report as an appendix rather than duplicating results in this report. The LTMP report contains a general analysis of the data for all five northern surveys and also includes the southern survey (Cairns to Townsville) that was conducted in 2002. The LTMP report will be updated biannually to incorporate each additional year of survey data. Unfortunately, the 2003 survey was cancelled due to an engine failure on the research vessel. The 2004 and 2005 surveys were, however, successfully completed and the results will be included in the 2006 update of the LTMP report.

4.3.3 Annual size distribution plots by species and gender

The size frequency distributions of tiger and endeavour prawns by species, gender and survey were plotted separately for the North Queensland and Torres Strait fisheries to provide information on the size (age) structure of the prawn stocks of each species at the start of each season. As the growth rates of male and female prawns are different they are plotted on separate histograms. The overall size distribution of brown tiger and blue endeavour prawns in the North Queensland east coast and Torres Strait sites were also compared.

4.3.4 Survey recruitment indices

All of the sites are trawled for one nautical mile; therefore, the number of prawns retained in each net at each site is a catch rate. As the same sites, vessel, nets and timing are used for each survey the sample catch rates provide a relative index of stock abundance (numbers) and biomass (weight) on the seabed. Based on the size distribution data from the surveys (section 5.4) and the published growth rates most of the prawns sampled during the February surveys are new recruits to the fishery. The sizes and growth rates suggest that most would have spawned in the previous late winter and spring (August–November). Due to the seasonal closures (December–February) most of these prawns would have been protected from fishing pressure until the start of the fishing season (1 March). Therefore, averaging the survey sample catch rates for each fishery provides a relative index of the main (March) recruitment to that fishery.

Both of the survey recruitment indices (abundance and biomass) were compared with industry-based measures of recruitment and subsequent catches in the fishery to test effectiveness of the surveys at monitoring relative changes in recruitment. The weight of prawns in each sample is based on the individual prawn carapace length measurements and the length weight relationships developed in section 4.3.1 for the six main species. The homogeneity of the trends in the recruitment indices between strata was also examined.

The catch of each net at each site is regarded as a replicate sample for that site and year combination, as the nets cover adjacent sections of seabed at the same time. Regarding the individual nets as replicates provides a measure of the variability of the catch rate for each site and year.

Only the two species of tiger and endeavour were examined for recruitment indices, as they are the primary target species in prawn trawl areas within the northern section of the GBR. The king prawns are essentially a by-product species of the tiger/endeavour fishery. There are areas further offshore between the reefs (off Townsville and near Cape York) that are targeted for red spot king prawns. However, the recruitment surveys did not include those areas.

The following filters were applied to the survey data analysis to exclude non-representative samples:

- Regular sites — some sites trawled during the early surveys were abandoned in the later surveys as it became obvious they were not on good trawl ground, or added little additional data and were logistically difficult to include in the sampling program.
- Quantitative samples — some samples have been classed as non-quantitative due to problems with the operation of the net during the trawl. Examples are a large shark or ray in the net or

the net bogging (full of mud and shell grit). Although the prawns in these samples were retained, where possible the sample catch rate is not representative of that site and year.

- Repeat 1 — on some occasions the trawls at some sites were repeated, if there were indications that the nets had not fished properly. An example is that in strong seas the nets tend to 'fly' if trawling with the wind or current. In these cases we then trawled in the opposite direction to see if it made a difference to the catch. The trawl (shot) that was considered as best representing the site at that time was labelled as repeat 1 and used in the analysis.

5 Results

5.1 Trends in the commercial catch and effort data

5.1.1 North Queensland

This section summarises the trends in the commercial catch and effort data for the section of the Queensland east coast encompassed by the annual recruitment surveys (15.5°S to 10.5°S). The data was stratified using the same CFISH grids as for the survey data (Table 2). Since the start of logbook records in 1988 the total fishing effort for this area has ranged from 11 800 to 21 300 days (Figure 5). Although the distribution of effort across the strata varies between years, on average the highest level of effort (45%) occurs in the 'Princess Charlotte Bay' stratum then the 'Middle' (29%) and 'Flattery' (24%) strata. The 'north' stratum has a relatively small (2%) level of fishing effort (Figure 5a).

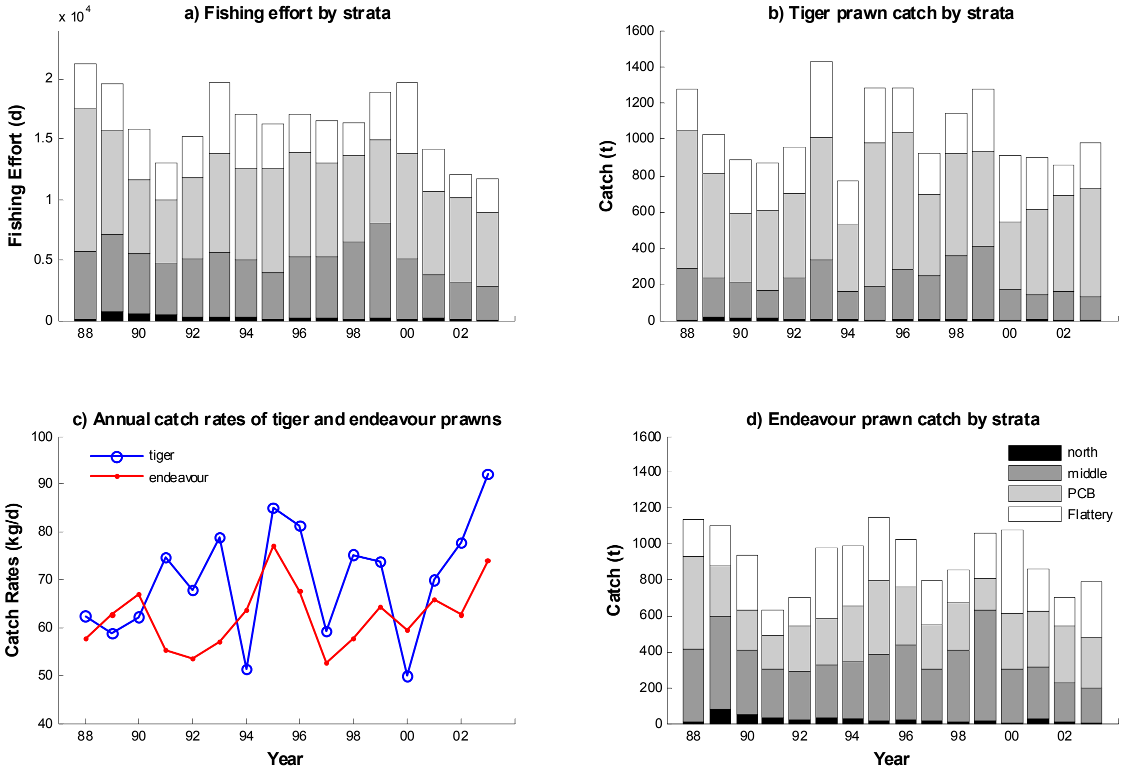

Figure 5 Trends in the fishery data from the section of Queensland east coast covered by the recruitment surveys.

In general the tiger and endeavour prawn catches reflect the distribution of fishing effort over years and strata. The total tiger prawn catch has varied between 770 and 1430 tonnes. An average of 51 percent and 27 percent of the tiger prawn catch came from the 'PCB' and 'Flattery' strata respectively (Figure 5b) indicating that they are the most productive sections of the fishery for tiger prawns. The very low tiger prawn CPUE for 1994, 1997 and 2000 suggest that these were years of low tiger prawn recruitment (Figure 5c). Since 2000, which had the lowest catch rate in the whole time-series, the annual tiger prawn catch rates has steadily increased.

The total endeavour prawn catch has varied between 627 and 1147 tonnes and the catch is more evenly distributed across the strata with 37, 31 and 31 percent coming from the 'middle', 'PCB' and 'Flattery' strata respectively (Figure 5d). The catch rate data suggests that 1992 and 1997 were years of low endeavour prawn recruitment (Figure 5c). Since 1997 the general trend in the annual catch rates has been upward.

The annual catch rate data in Figure 5c are based on records that represent ‘targeted’ effort directed towards tiger or endeavour prawns. The process of filtering the records is described in the methods section and is the same as that used by Turnbull and Gribble (2003). The aim was to remove records that are more likely to be associated with targeting banana or red spot king prawns and records that only represent a partial night of fishing. Some of the records, especially for the ‘north’ stratum are associated with fishing further offshore for red spot king prawns.

The March and April average vessel catch rates (CPUE) are a measure (relative index) of recruitment at the start of the fishing season that is based on the commercial fishery data. The North Queensland east coast tiger prawn catches for the first four months of the season and annual catch generally mirror the trends in March, April and annual CPUE (Figure 6a, b). The reduced catches during the years 2001 and 2002 (despite increasing catch rates) were a result of decreased annual fishing effort. The reduction in fishing effort during these years was the result of changes in the management arrangements for the fishery. The introduction of ‘days of fishing’ access linked to each licence limited the number of nights that vessels could work each season. In addition a licence buyback scheme reduced the size of the fleet.

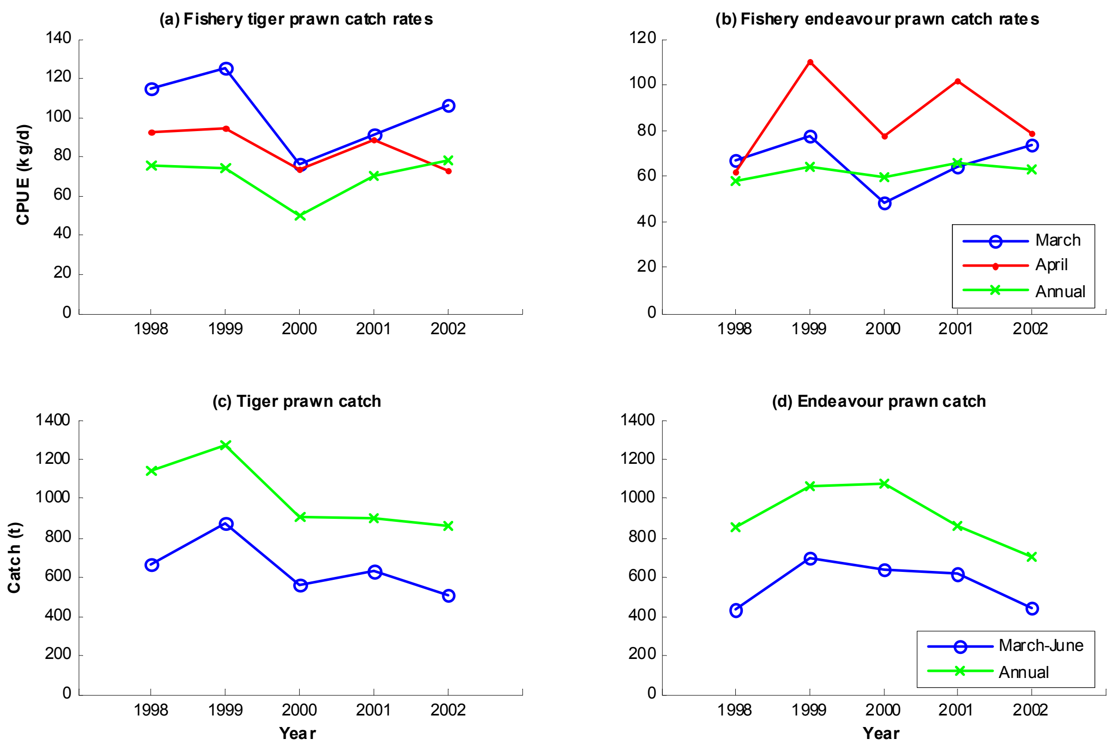

Figure 6 Trends in Queensland northern east coast fishery indices of stock status for the years 1998–02; (a) tiger prawn CPUE for March, April and annual, (b) endeavour prawn CPUE, (c) tiger prawn catch for the first four months of the season and annual, (d) endeavour prawn catch for the first four months of the season and annual.

A comparison of Figure 6(b) and Figure 6(d) indicates that the endeavour prawn CPUE indices are a poor match with both the annual and early season (March–June) catches. This is probably a result of the reduced fishing effort during 2001–02 and fishers primarily targeting tiger prawns with the result that the endeavour prawn catch is to some extent a byproduct of targeted tiger prawn fishing. The April CPUE for endeavour prawn is generally higher and more variable that the March CPUE indicating that the main recruitment of endeavour prawns occurs during March. This also suggests that for endeavour prawns the April CPUE is the best recruitment index.

Figure 7 plots the data presented in Figure 6 as relative changes standardised to 2001, which was an average year in terms of catches and catch rates for both tiger and endeavour prawns. The March CPUE for tiger prawns (Figure 7a) is higher and more variable than the April CPUE, which suggest that the March commercial catch rates provide the best tiger prawn recruitment index.

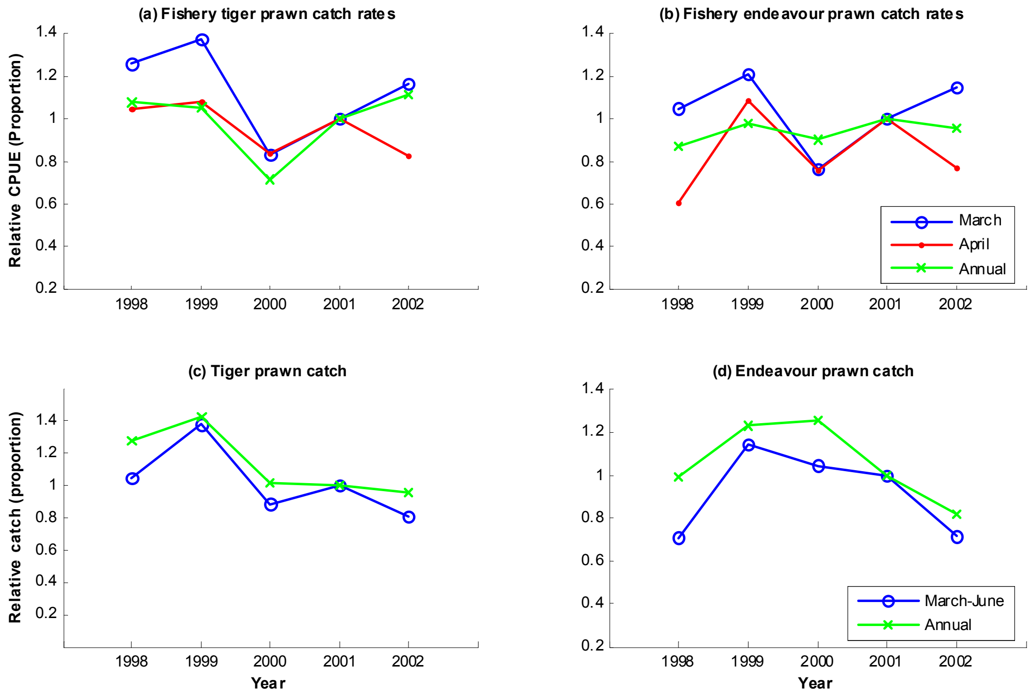

Figure 7 Trends in Queensland northern east coast fishery indices of stock status for the years 1998–02, shown as relative (proportion) change standardised to 2001.

The April endeavour prawn CPUE (Figure 7) indicates endeavour prawn recruitment has oscillated up and down during the period of the surveys with 1998 as the lowest recruitment and 1999 as the highest. Although the index suggests that 2000 was a year of low recruitment this does not show up in the catches which were relatively high. Examination of the monthly endeavour catch and effort data for 2000 suggest that there was a late recruitment of endeavour prawns during May to June and that effort during May to September of 2000 was higher than average. This would explain why the annual catch for 2000 was good despite a lower recruitment index for the start of the season.

Summary

The North Queensland commercial fishery data that spans the survey years 1998–2002 indicates that tiger prawn recruitment was slightly higher in 1999 than 1998 then low in 2000 followed by an increase during the years 2001–02. In contrast to tiger prawns the April CPUE for endeavour prawns may provide the best index of recruitment. The commercial data indicates that endeavour prawn recruitment has oscillated up and down during the period of the surveys with 1998 as the lowest recruitment and 1999 as the highest. Changes in the management arrangements for the North Queensland fishery have impacted on the relationship between the commercial recruitment indices and annual catches by limiting the fishing effort after 1999.

5.1.2 Torres Strait

Since the start of compulsory logbook records in 1989 the Torres Strait tiger prawn catch has varied between 396 and 965 tonne per year while endeavour prawn catch has varied between 435 and 1511 tonne. Fishing effort has also varied from a low of 5700 days in 1990 to a high of 11 900 days in 1992 (Figure 8).

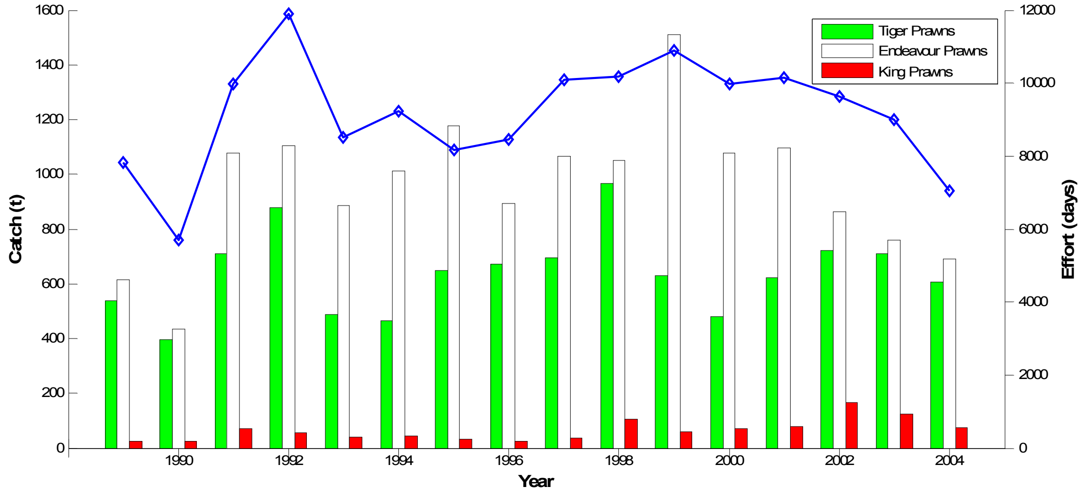

Figure 8 Torres Strait prawn catches by species (columns) and effort (line).

The 1998 tiger prawn and 1999 endeavour prawn catches (Figure 8) are the highest recorded for the years 1989–04. In contrast, the 2000 season had the second lowest tiger prawn catch and lowest tiger prawn catch rate (CPUE) since 1989
(

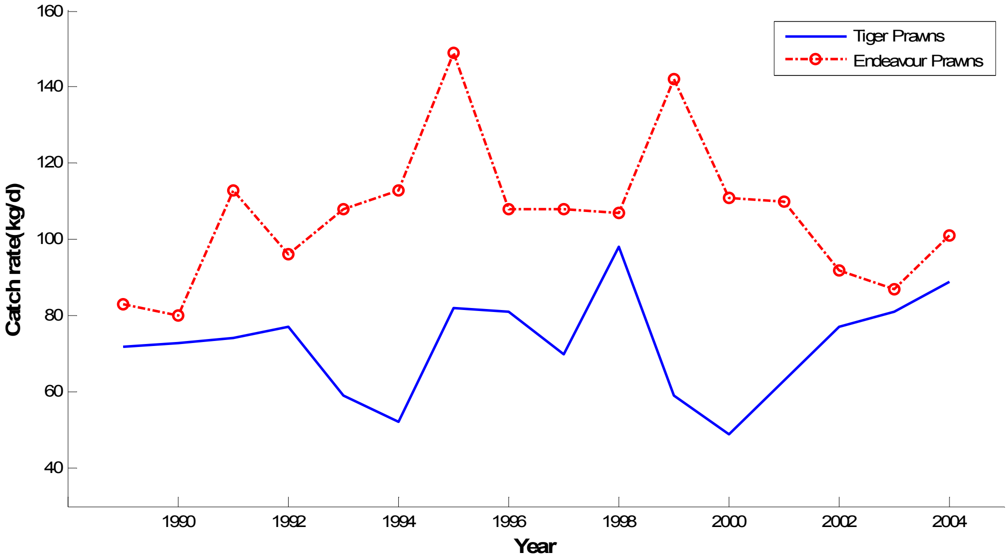

Figure 9). During the period 2000–03 annual tiger prawn catch increased as both the days fished and endeavour prawn catch decreased. The annual catch rate of tiger prawns has also steadily increased since the low in 2000 with the 2004 season having the highest tiger prawn catch rate since the peak year of 1998 (Kung et al. 2005).

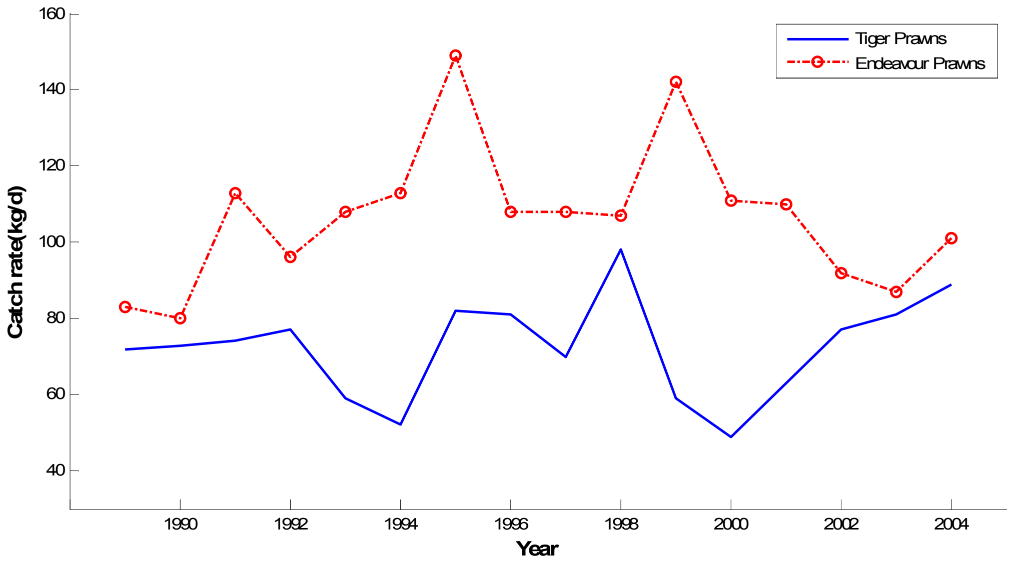

Figure 9 Yearly catch rates (CPUE) for tiger and endeavour prawns in Torres Strait.

The Torres Strait tiger prawn catches for the first four months of the season and annual catch generally mirror the trends in March, April and annual CPUE (Figure 10a, c). The March CPUE index is generally higher than the April CPUE index, indicating that the March CPUE is the best index of recruitment based on the commercial data. In 2001, the April tiger prawn CPUE (Figure 10a) was slightly higher than the March CPUE, indicating that tiger prawn recruits were still moving into the fishery during March. Although the annual tiger prawn CPUE is lower than the March and April CPUE indices it still closely matches the trend in the annual catch. These observations support the view that in the Torres Strait fishery the tiger prawn stock available to the fleet each year is largely determined by recruitment into fishable areas during February to April.

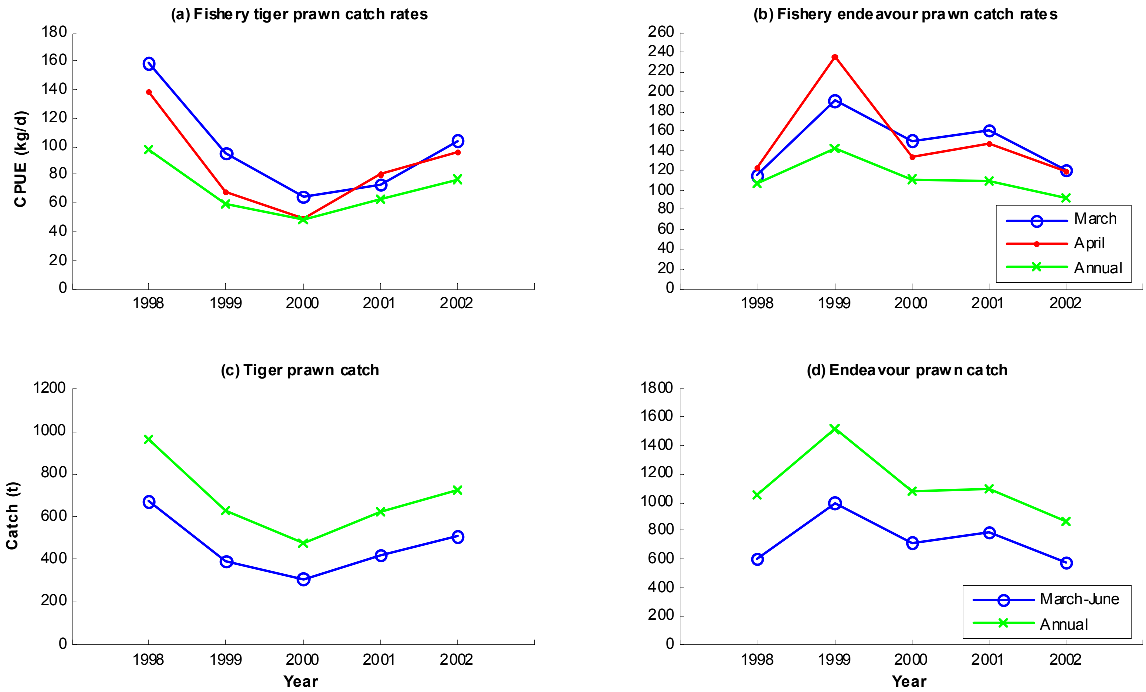

Figure 10 Trends in Torres Strait fishery indices of stock status for the years 1998–02; (a) tiger prawn CPUE for March, April and annual, (b) endeavour prawn CPUE for March, April and annual, (c) tiger prawn catch for the first four months of the season and annual, (d) endeavour prawn catch for the first four months of the season and annual.

The endeavour prawn recruitment indices (March and April CPUE) also closely match the trend in the annual catch of the fishery (Figure 10). The 1999 April endeavour prawn CPUE was much higher than the March 1999 CPUE. This indicates that large numbers of endeavour prawn recruits were continuing to feed into the fishery from the closed areas during March, which accounts for the exceptionally high 1999 endeavour prawn harvest.

Figure 11 plots the same data presented in Figure 10 as relative changes standardised to 2001, which was an average year in terms of catch and CPUE for both tiger and endeavour prawns. The trend in the catch for March-June and the total annual are almost identical for both tiger and endeavour prawns. The plots in Figure 11 show that for both tiger and endeavour prawns the trends in the March CPUE, April CPUE and Annual CPUE indices are all very similar. As for North Queensland the March CPUE for tiger prawns appears to be the best index of recruitment, whereas the April CPUE may be the better index for endeavour prawns.

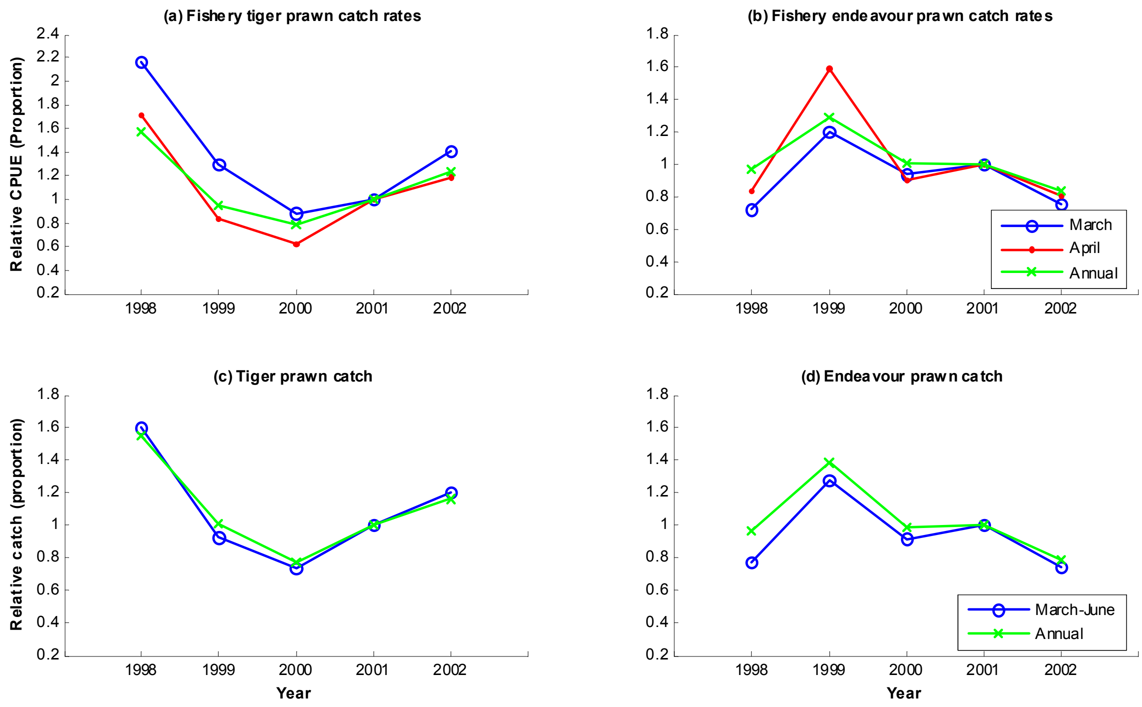

Figure 11 Trends in Torres Strait fishery indices of stock status for the years 1998–02, shown as relative (proportion) change standardised to 2001.

Summary

The Torres Strait commercial fishery data that spans the survey years 1998–2002, indicates that tiger prawn recruitment rapidly swung from a very high level in 1998 to one of the lowest in 2000, then returned to average level in 2002. In contrast, endeavour prawn recruitment was average with the exception of 1999 which was a year of high recruitment.

5.2 Length-weight relationships

Both the standard two-parameter model ($W = aL^b$) and a three-parameter model that permits a non-zero length at weight zero ($W = k + aL^b$) were fitted to the data. As the addition of the third parameter produced a negligible improvement in the fit of the model we applied the principle of 'parsimony' and used the two-parameter model to estimate the weights of individual prawn records from the carapace length measurements. The parameter estimates, standard error of the estimates, sample size and measures of model fit (percentage variance accounted) are listed for each species and gender in Table 4 for the two-parameter model and in Table 5 for the three-parameter model.

Table 4 Length-weight parameter estimates for the two-parameter model.

Species	Gender	a	Standard error	b	Standard error	Percentage variance accounted	Sample size (n)
P. esculentus	f	0.0035240	0.0000982	2.60835	0.00781	98.9	1533
P. esculentus	m	0.0022010	0.0000783	2.75580	0.01050	98.5	1326
P. semisulcatus	f	0.0034420	0.0001070	2.59795	0.00864	98.7	1255
P. semisulcatus	m	0.0018883	0.0000807	2.78390	0.01260	98.1	1141
M. endeavouri	f	0.0029297	0.0000785	2.62806	0.00779	99.1	1829
M. endeavouri	m	0.0016204	0.0000529	2.83460	0.01020	98.7	1742
M. ensis	f	0.0024740	0.0001800	2.595 50	0.02110	98.7	288
M. ensis	m	0.0018930	0.0001530	2.69880	0.02570	97.8	326
P. longistylus	f	0.0016840	0.0001050	2.69020	0.01750	97.9	574
P. longistylus	m	0.0010797	0.0000846	2.83670	0.02320	97.2	530
P. latisulcatus	f	0.0017940	0.0001380	2.68080	0.02120	97.8	470
P. latisulcatus	m	0.0010179	0.0000988	2.85640	0.02780	96.8	442

Table 5 Length-weight parameter estimates for the three-parameter model.

Species	Gende r	K	Standard error	a	Standard error	b	Standard error	Percentage variance accounted	Sample Size (n)
P. esculentus	f	-2.7330	0.2470	0.008539	0.000671	2.3814	0.0203	99.0	1533
P. esculentus	m	-1.8800	0.2800	0.005206	0.000644	2.5247	0.0333	98.5	1326
P. semisulcatus	f	-2.2460	0.3280	0.006924	0.000696	2.4209	0.0256	98.8	1255
P. semisulcatus	m	-1.1960	0.3550	0.003445	0.000600	2.6219	0.0471	98.2	1141
M. endeavouri	f	-0.8755	0.0809	0.005089	0.000280	2.4788	0.0151	99.2	1829
M. endeavouri	m	-0.5941	0.0738	0.002867	0.000214	2.6704	0.0218	98.8	1742
M. ensis	f	-0.0410	0.2300	0.002558	0.000502	2.5866	0.0533	98.7	288
M. ensis	m	-0.3800	0.2440	0.003016	0.000895	2.5642	0.0862	97.9	326
P. longistylus	f	-0.3970	0.3950	0.002081	0.000448	2.6357	0.0559	97.9	574
P. longistylus	m	-1.1540	0.4920	0.002542	0.000881	2.6052	0.0938	97.3	530
P. latisulcatus	f	-3.3560	0.7920	0.006330	0.001750	2.3636	0.0695	97.9	470
P. latisulcatus	m	-3.1490	0.9060	0.004910	0.001980	2.4460	0.1050	96.9	442

Scatter plots of the individual length and weight data (Figure 12) show a fairly tight relationship for all six species. The smaller size and weight of the males of each species is also clearly illustrated in the scatter plots. Tiger prawns reach the largest weights and carapace lengths while the false endeavour is the smallest and lightest of the six major commercial species. Although king prawns grow to similar sizes (carapace length) to the tiger prawn species they are lighter for an equivalent carapace length. This reflects morphometric differences between the species, that is, king prawns have a larger head relative to the body size than for tiger prawns.

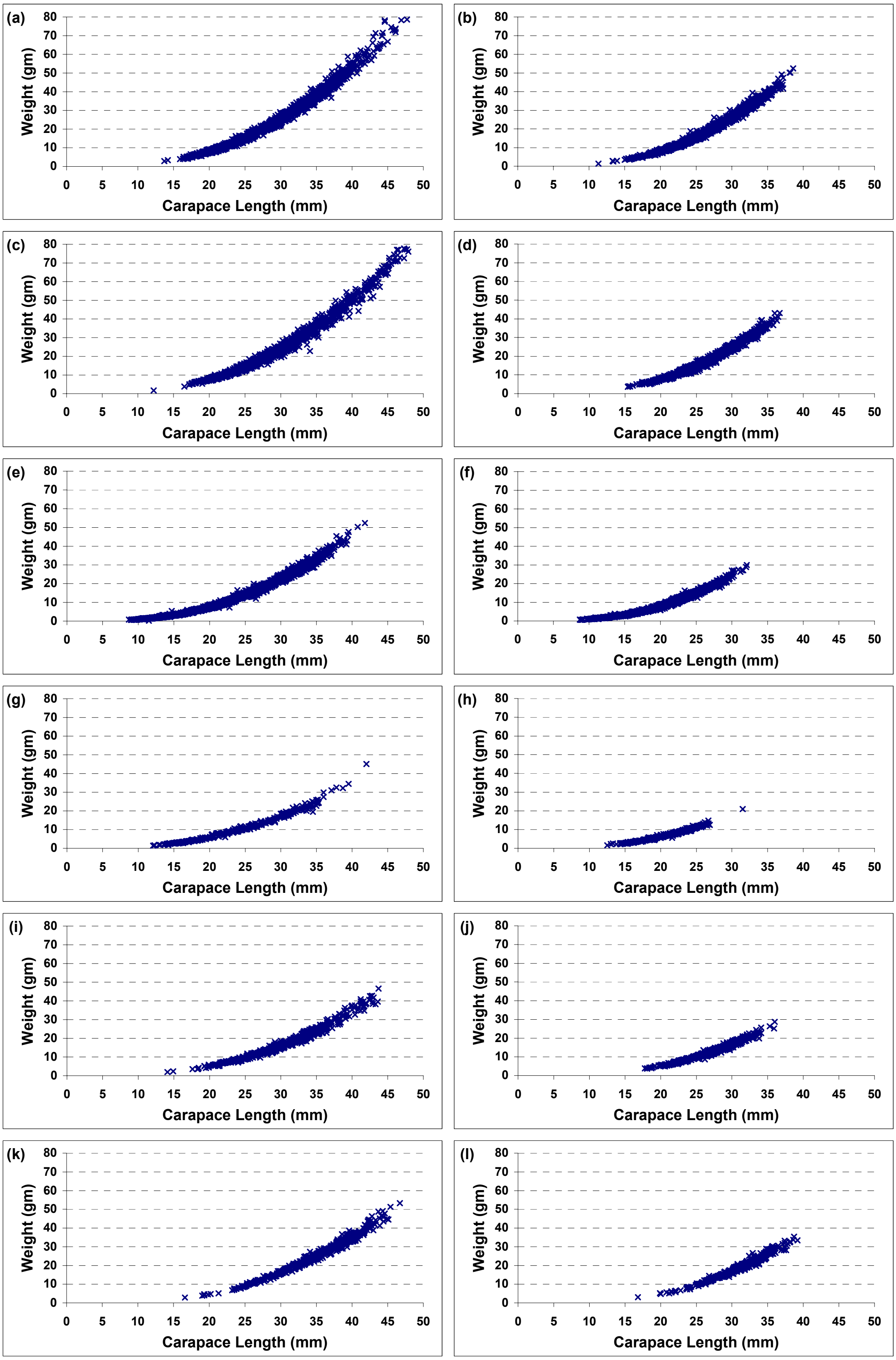

Figure 12 Scatter plots of length-weight data. (a) female brown tiger, (b) male brown tiger, (c) female grooved tiger, (d) male grooved tiger, (e) female blue endeavour, (f) male blue endeavour, (g) female false endeavour, (h) male false endeavour, (i) female red spot king, (j) male red spot king, (k) female western king, (l) male western king.

5.3 Survey Recruitment Indices

As the surveys are conducted at the end of a three-month seasonal closure most of the prawns can be consider as recruits to the fishery. The mean number and mean weight of prawns retained in each grouping of sites (Fishery and strata) provides a fishery-independent index of the recruitment of each species. The species data can also be pooled to provide indices for each of the commercial catch categories.

The average survey catch rate (numbers/sample) for each of the commercial categories (tiger, endeavour and king), and the two species that comprise each of those catch categories, are plotted below. The fact that the Torres Strait catch categories are essentially single species is clearly shown in the right hand plots. The 95 percent confidence interval for each data point is fairly tight indicating that survey results provide reliable estimates of the relative variation between years in the abundance of each species.

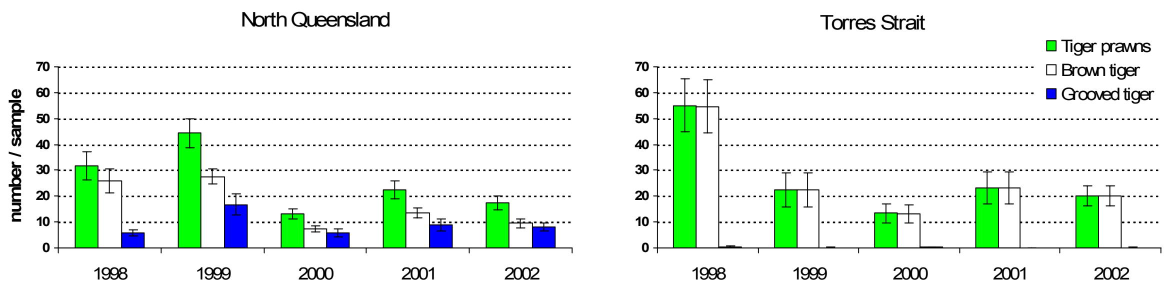

Figure 13 Survey catch rates (CPUE) of tiger prawns as a group and by species. The error bars show the 95% confidence intervals of the estimates of abundance.

The trends in tiger prawn abundance are quite different between North Queensland and Torres Strait. The survey results indicate very high abundances in 1998 for Torres Strait. In contrast the tiger prawn survey results for North Queensland suggest that 1998 was only slightly above the average for 1998–02 and that 1999 was the year of higher abundance. The survey results also suggest that the increase in tiger prawn abundance for North Queensland in 1999 is largely due to a higher abundance of the grooved tiger prawn. There is only a small increase in the catch rate of the brown tiger prawn between 1998 and 1999 and the difference is within the error bars of both estimates. This demonstrates the value of the surveys in that they can provide information on recruitment at a species level. This type of information is not available from the commercial fishery data.

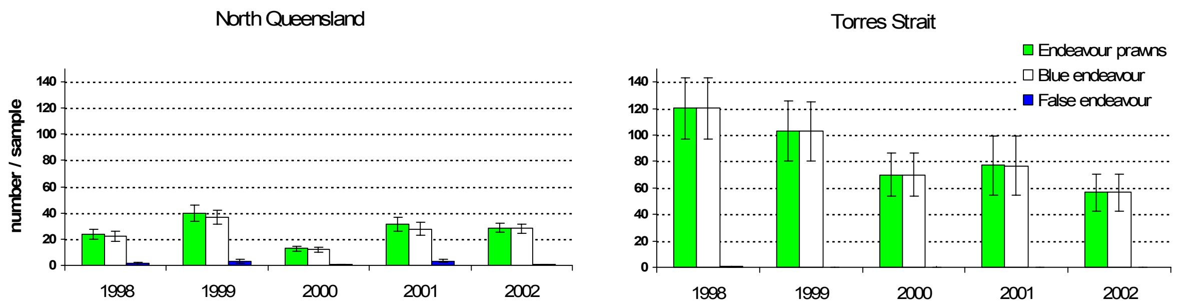

Figure 14 Catch rates (CPUE) of endeavour prawns as a group and by species. The error bars show the 95% confidence intervals of the estimates of abundance.

Figure 14 suggests the abundance of the endeavour prawn in Torres Strait is much higher than in North Queensland. This matches with fishery data which also shows higher catch rates for endeavour prawns in Torres Strait. The data also indicates that the false endeavour prawn forms a relatively small component of the North Queensland endeavour prawn catch.

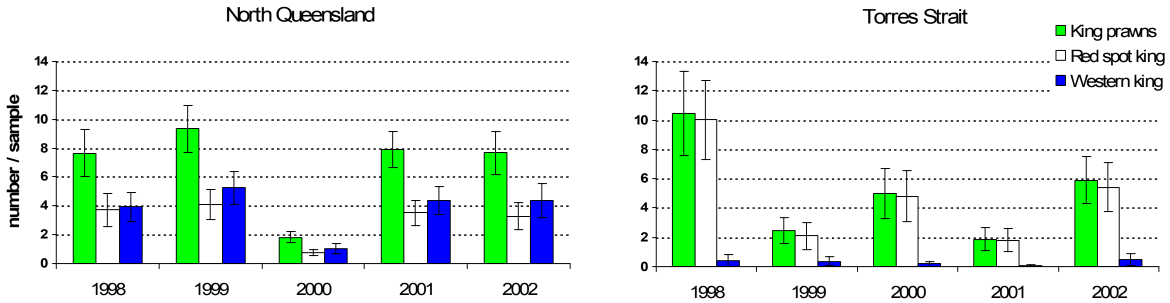

Figure 15 Catch rates (CPUE) of king prawns as a group and by species. The error bars show the 95% confidence intervals of the estimates of abundance.

Although the abundances of king prawn in North Queensland and Torres Strait are similar (Figure 15), the king prawn catch in the Torres Strait consists mainly of the red spot king prawn. In contrast the catch from North Queensland is composed of roughly equal numbers of both king prawn species. The trend in abundance of red spot king prawns in Torres Strait is also different to that observed on the North Queensland east coast. In Torres Strait the abundance of the red spot king prawn was high in 1998 and low in 1999 and 2001. This contrasts with North Queensland where red spot king prawn abundance was low in 2000 and roughly the same for the other years.

5.4 Size frequency data

The size frequency distribution for each species and gender based on pooled data for all of the recruitment surveys is shown in the attached LTMP Northern Prawns report 1998–2002. The yearly size frequency plots for brown tiger, grooved tiger and blue endeavour prawns are presented in this report as they provide additional information on recruitment. The size distribution plots are indicative of the age structure of the stocks of each species at the start of each season.

5.4.1 Comparison of North Queensland and Torres Strait size data

Figure 16 compares the size distribution of the brown tiger prawn and the blue endeavour prawn in the North Queensland and Torres Strait survey sites. The higher frequency of the smaller size classes in the Torres Strait data is due to the relatively larger number of sites within closed areas in Torres Strait. The strategy of focusing survey sites in areas of high juvenile abundance in Torres Strait was facilitated by the permanent (West of Warrior Closure) and spatial/temporal (East of Warrior Closure) closures that are designed to protect much of the juvenile stock from fishing. Although the North Queensland east coast has a few permanently closed areas designed to protect juvenile prawns along most of the coast the juvenile prawns occur in areas that open to fishing at the start of the season.

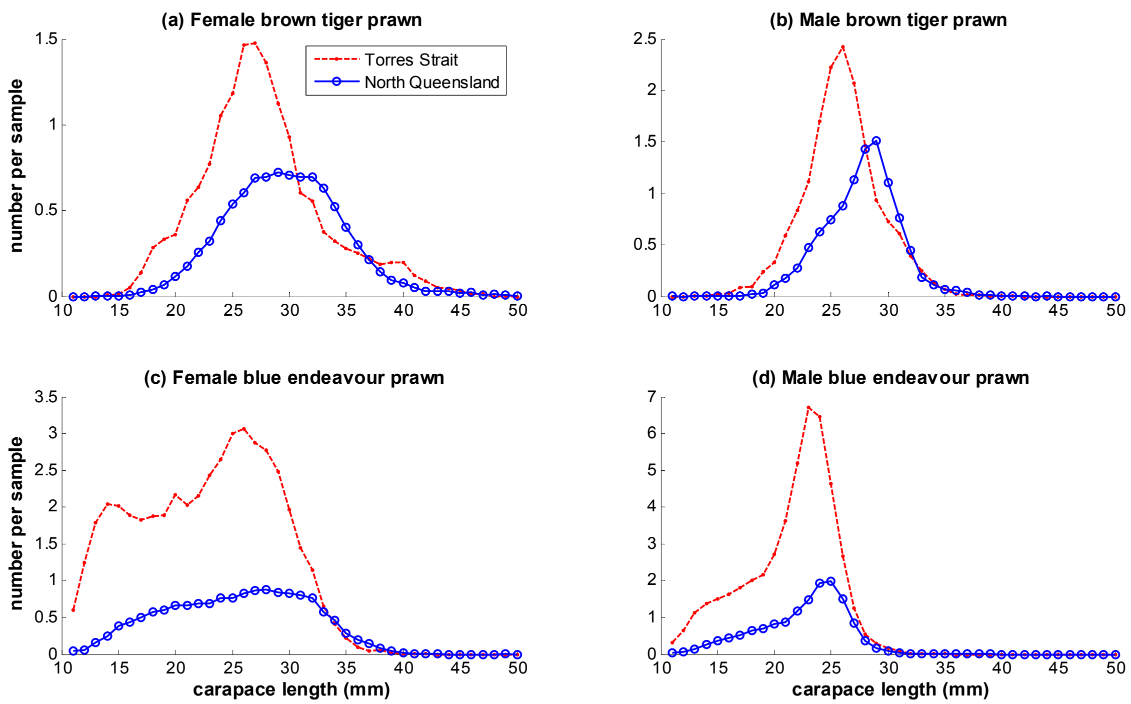

Figure 16 Comparison of the size distributions of the brown tiger prawn and the blue endeavour prawn between the North Queensland east coast and Torres Strait survey sites.

5.4.2 North Queensland

As the stocks of tiger and endeavour prawns on the North Queensland east coast are multi-species, the data for the two most abundant tiger species and the two most abundant endeavour species are presented.

5.4.2.1 Brown Tiger Prawns

The size frequency plots for the brown tiger prawn in North Queensland (Figure 17) indicates that, although there is a wide range of sizes (and ages) from very small recruits to adult prawns that have survived from the end of the previous fishing season, the bulk of the prawns are of a size that indicates an age of four to seven months. These are the new recruits to the fishery that were spawned in the previous late winter/spring period (August to November). The growth rates for brown tiger prawns (Watson and Turnbull, 1993) indicate that a male brown tiger prawn of four to seven months age would have a Carapace Length (CL) of 21–29 mm, while a female would have a CL of 25–34 mm. The size frequency plots also indicate that recruitment is complex, consisting of recruits from spawning over a period of three or four months.

The east coast size frequency plots for the brown tiger prawn (Figure 17) indicate that the stronger recruitment of tiger prawns in 1998 and 1999 (section 5.1.1) consisted of two and possibly more age cohorts. In contrast, the 2000 size plots indicates a weak recruitment and the 2001 plots suggests there was only one main age cohort contributing to the recruitment. The slight shift to the right in the 2002 size distributions compared with 2001 is probably due to the delayed timing of the 2002 survey, which occurred two weeks after the start of the season.

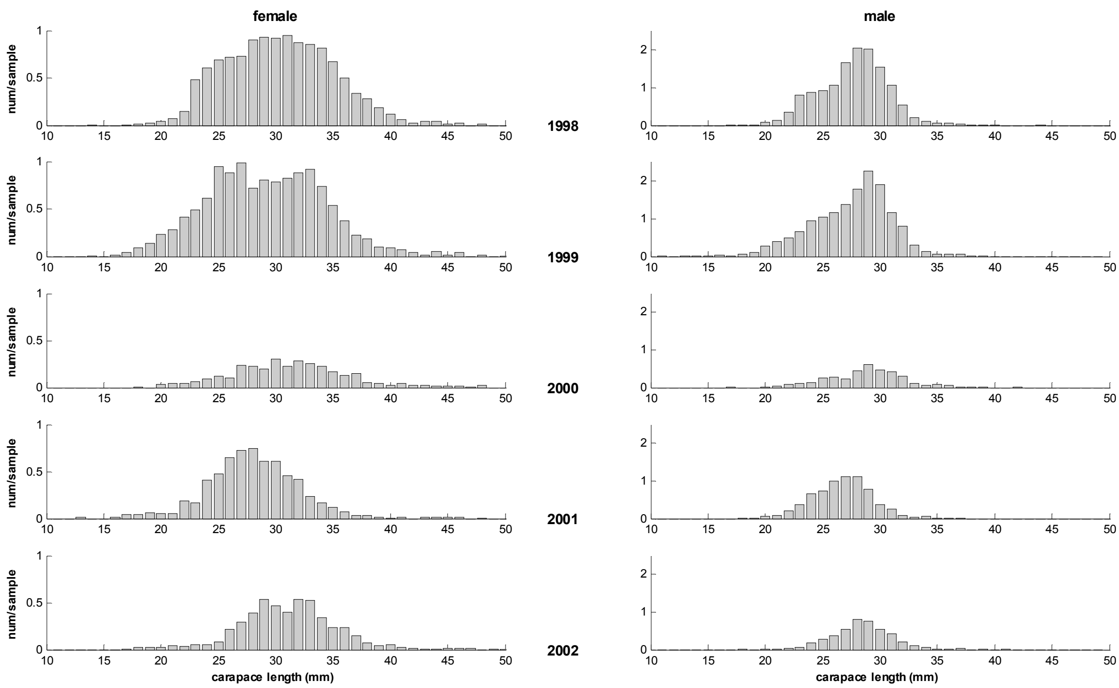

Figure 17 Survey size frequency distributions of the brown tiger prawn from the Queensland east coast survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes scales are different for males and females.

5.4.2.2 Grooved Tiger Prawn

The survey size plots for 1998 indicate both a weaker recruitment (lower numbers of 20–30 mm CL males and 25–34 mm CL females) and a slightly higher abundance of adult grooved tiger prawns in the fishery at the start of the season than for the subsequent surveys (Figure 18). In contrast, the higher abundances in the size frequency plots for 1999 indicate a higher level of recruitment than for the other years. This, combined with the slightly stronger brown tiger prawn recruitment in 1999, would account for the good tiger prawn season that is evident in the commercial fishery data for 1999 (section 5.1.1).

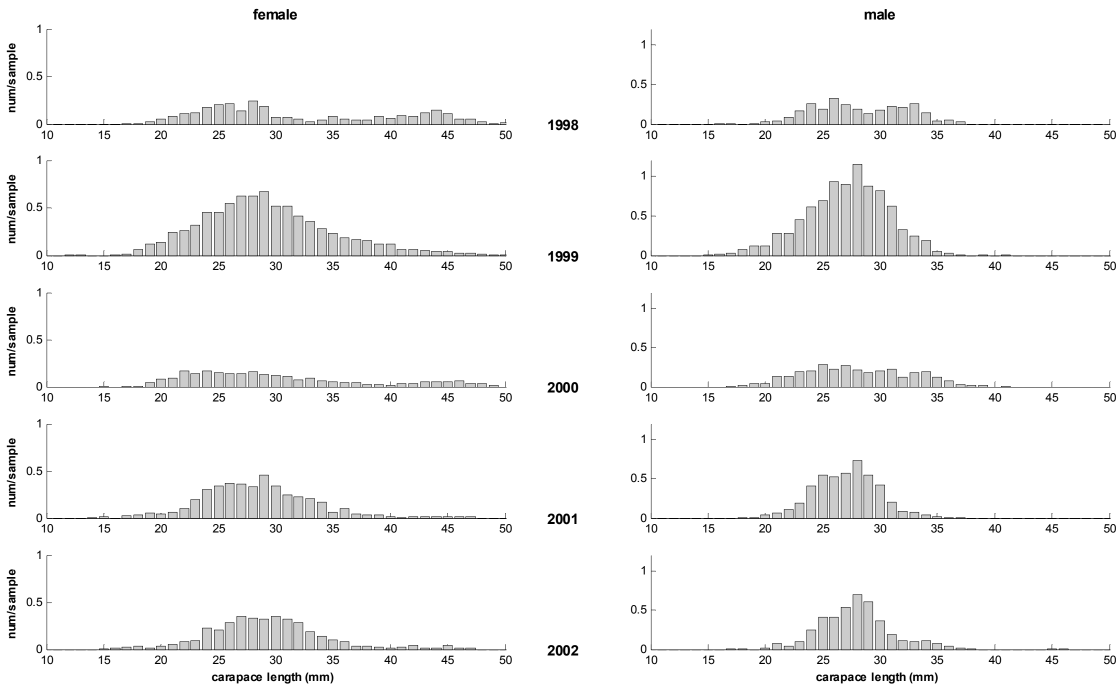

Figure 18 Survey size frequency distributions of the grooved tiger prawn from the Queensland east coast survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes scales are different for males and females

A comparison of Figure 17 and Figure 18 shows that the average number of grooved tiger prawns in the samples from the Queensland east coast survey sites is lower than for brown tiger prawns. This is also clearly shown in Figure 13 (section 5.3), which shows the individual species catch rates for each survey.

5.4.2.3 Blue Endeavour Prawn

The size frequency distribution plots (Figure 19) for the blue endeavour prawn indicate that recruitment consists of a range of sizes (ages) and there are at least two and possibly more age cohorts contributing to recruitment. The plots also indicate that 2000 was a year of low recruitment as the abundances of endeavour prawns in all size classes are much lower than for the other years. The size distribution of females and males in 1999 is bimodal and abundance in most size classes is higher than for the other years, suggesting a stronger recruitment. Again the shift to the right of the size distributions of the 2002 plots may be due to the later timing of the 2002 survey.

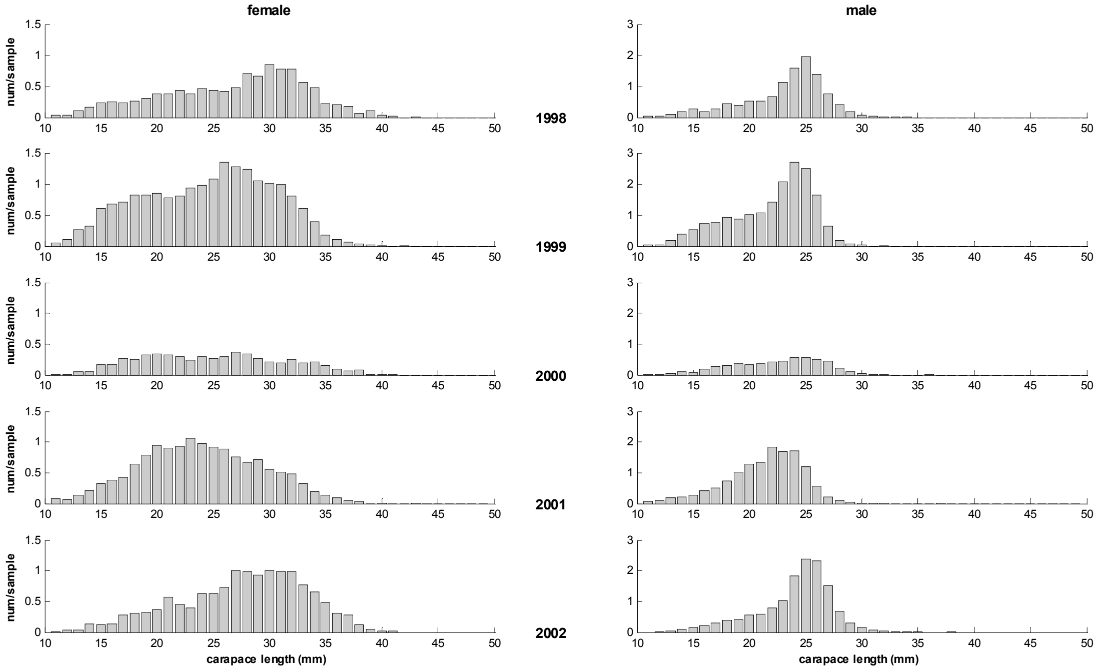

Figure 19 Survey size frequency distributions of the blue endeavour prawn from the Queensland east coast survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes scales are different for males and females.

A comparison of Figure 19 and Figure 20 shows that the blue endeavour prawn comprises the bulk of the endeavour prawn catch for the Queensland east coast survey sites. This is also clearly shown by the individual species catch rates in Figure 14 (section 5.3).

5.4.2.4 False endeavour prawn

Although the lower abundances of this species make it difficult to comment on the annual variation in recruitment the plots suggest that 1999 and 2001 were years of slightly higher recruitment for this species. This is also indicated in Figure 14 (section 5.3).

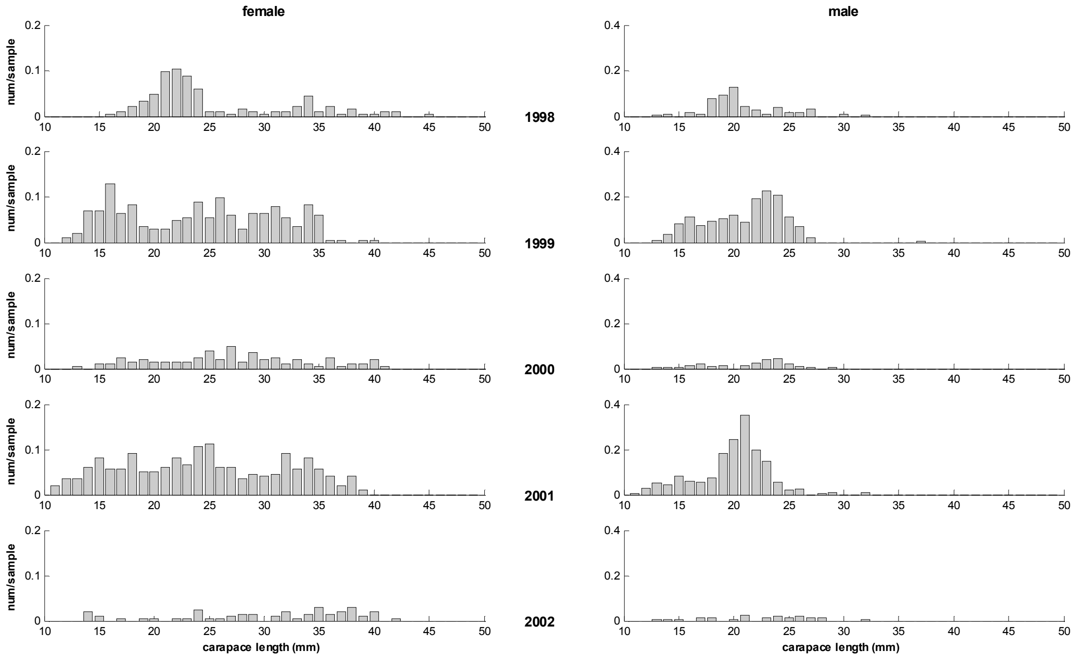

Figure 20 Survey size frequency distributions of the false endeavour prawn from the Queensland east coast survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes scales are different for males and females.

5.4.3 Torres Strait

As the stocks of tiger and endeavour prawns in Torres Strait consist almost exclusively of the brown tiger prawn (*Penaeus esculentus*) and the blue endeavour prawn (*Metapenaeus endeavouri*) only the length frequency data for these two species have been presented.

5.4.3.1 Brown Tiger Prawn

As for North Queensland, the size frequency plots for the brown tiger prawn in Torres Strait (Figure 21) indicates that although there is a wide range of sizes (and ages) — from very small recruits to adult prawns — that have survived from the end of the previous fishing season, the bulk of the prawns are of a size that indicates an age of four to seven months.

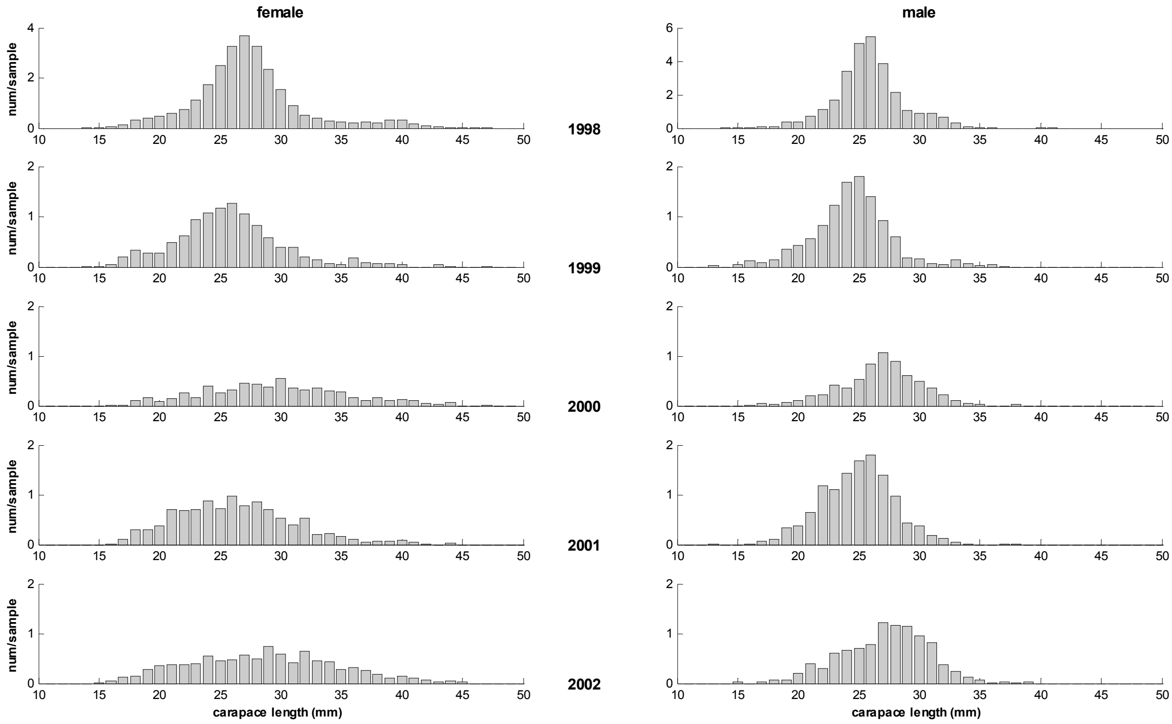

Figure 21 Survey size frequency distributions of the brown tiger prawn from Torres Strait survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes for 1998 is scaled different to the other years due to the high abundances that occurred in the 1998 survey.

Due to the high number per sample for the 1998 data it was necessary to use a different scaling on the Y-axis for the 1998 plots. The Torres Strait size frequency plots for brown tiger prawn indicate a very strong recruitment in 1998 that corresponds with the year of highest commercial tiger prawn catch and catch rates (section 5.1.2). Similarly, the Torres Strait survey data indicates a low recruitment in 2000 that corresponds with a year of low catch and the lowest annual catch rate recorded in Torres Strait for tiger prawns. As for North Queensland the 2002 plots are slightly shifted to the right reflecting the later timing of the survey.

5.4.3.2 Blue Endeavour Prawn

The size frequency plots for the blue endeavour prawn in Torres Strait (Figure 22) also show a wide range of sizes reflecting a range of ages in the survey samples. Most of the size distributions are clearly multi-modal indicating that for this species recruitment to the fishery consists of at least two main age (monthly) cohorts.

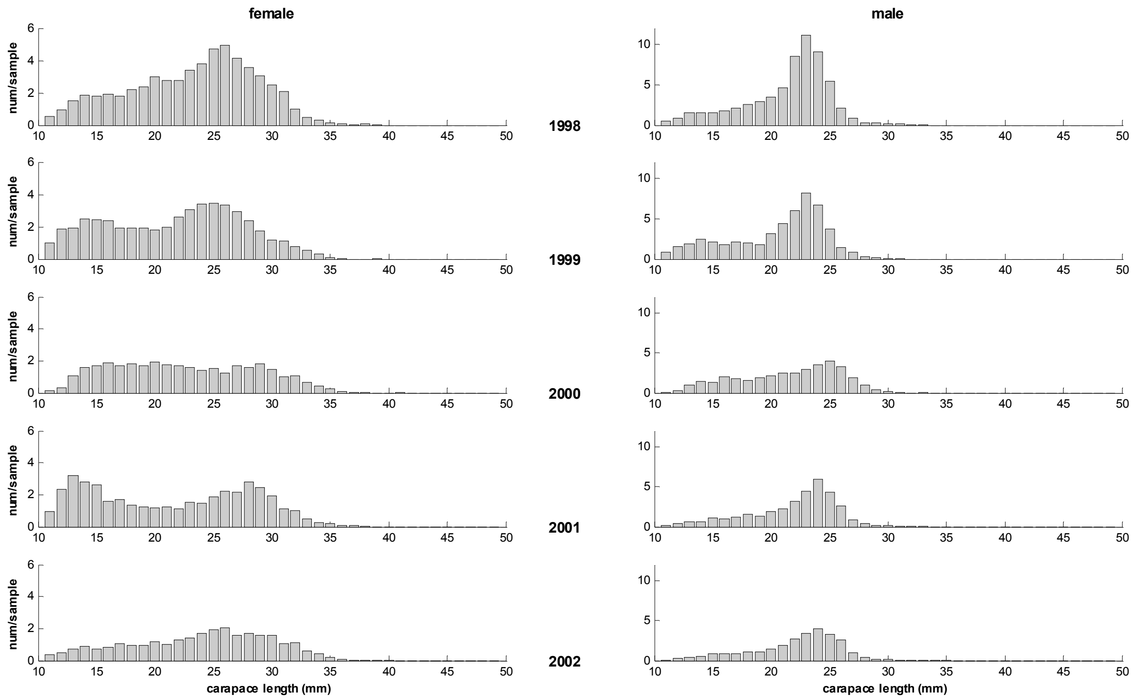

Figure 22 Survey size frequency distributions of the blue endeavour prawn from the Torres Strait survey sites. The figures show the mean number per sample for each carapace length class by gender and survey. The Y-axes scales are different for males and females.

The fishery data (section 5.1.2) suggests that 2001, and especially 1999, were years of higher endeavour prawn recruitment. The survey size plots for those years indicate a second strong cohort of very small juveniles in the 10–20 mm carapace size range. A gear selectivity study by Sterling et al. (1990) in Torres Strait indicates that retention of brown tiger and blue endeavour prawns in standard trawl nets decreases with size at carapace lengths below 25 mm. Therefore, the presence of many small animals in the survey samples in the size range 10–20 mm CL is indicative of higher densities on the seabed.

5.5 Comparison of recruitment indices with fishery data

The survey recruitment indices for tiger and endeavour prawns were compared with the industry-based estimate of recruitments; March and April average daily vessel catch rates (CPUE). This was done to check whether the survey recruitment indices are a reliable index of recruitment by investigating the extent to which they match with and explain the trends in commercial catches and catch rates.

5.5.1 North Queensland

Figure 23 compares the North Queensland survey recruitment indices, based on abundance (numbers) and biomass (weight), with the fishery indices of recruitment (March CPUE and April CPUE). As for the figures in section 5.1.1 the data has been plotted on a relative abundance (proportional) scale standardised to the 2001 year.

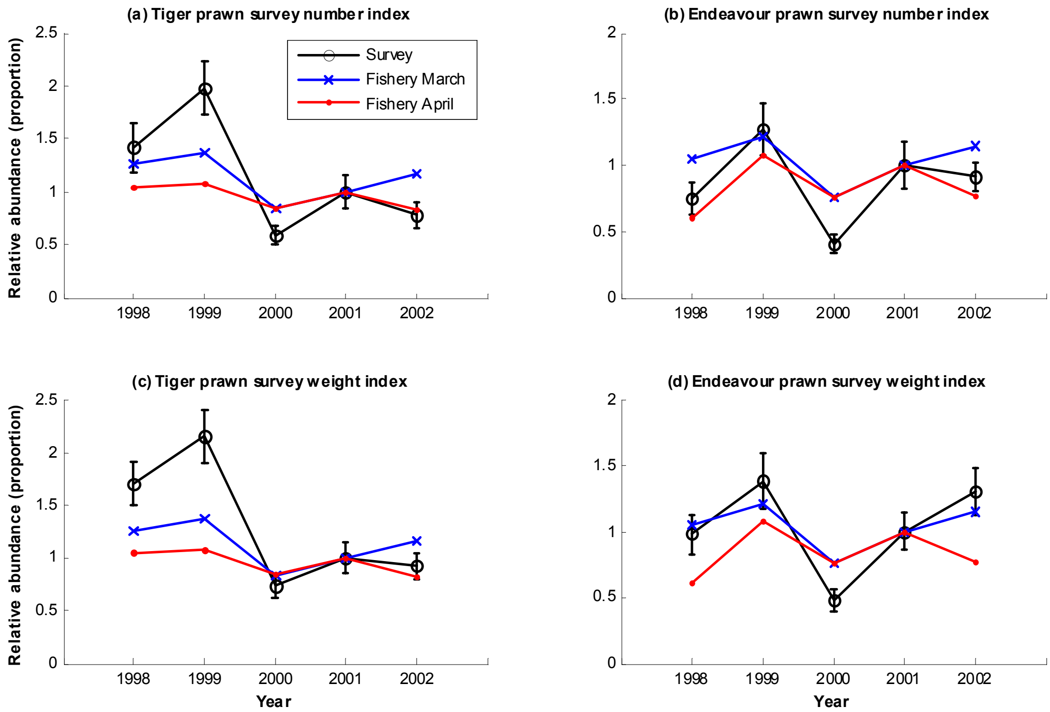

Figure 23 Trends in the North Queensland east coast tiger and endeavour prawn survey indices compared with the March and April commercial catch rates data. The error bars represent the 95% confidence interval of the survey estimates.

Although the trends in the survey indices generally match the trends in the fishery indices (Figure 23) the relative variation between years in the survey indices is much larger than the relative variation in the fishery indices. The tiger prawn survey indices suggest a strong recruitment for 1999 and a low recruitment for 2000 that matches the trend in the March CPUE and trends in annual catch (Figure 6). The survey indices for the years 1998 and 1999 are, however, much higher than the fishery indices. The trend in the survey number index for endeavour prawn is a good match to the April CPUE with the exception of the 2000 season where the survey has over-estimated the decline in recruitment when compared with the fishery index.

Unlike the Torres Strait survey data, the north Queensland survey results do not clearly show the same over-estimation of the 1998 tiger and endeavour prawn survey catch rates (section 5.5.2). Although the

1998 tiger prawn survey estimates are slightly higher than the fishery index the 1999 survey estimates are much higher than 1999 fishery index. In addition, the 1998 endeavour prawn survey indices are similar to the fishery indices. The North Queensland survey data, therefore, suggests that the change in otter boards between 1998 and 1999 surveys may have had less of an impact on the survey catch rates than is indicated by the Torres Strait data.

This is more variation between the strata in the North Queensland fishery (Figure 24) than for the Torres Strait fishery. This is to be expected given the larger geographic area of the fishery. A consistent difference is the lower tiger prawn index for the 'north' stratum. This matches with fishery data (Figure 5) that indicates the 'north' stratum has a much lower effort and catch than the other strata. This area appears to be a transition zone between the north Queensland and Torres Strait prawn fisheries. In terms of tiger and endeavour prawns the species composition of the 'north' stratum is closer to that of the Torres Strait (Turnbull et al. 2004). The tiger and endeavour prawns in this area consist, as for the Torres Strait fishery, almost entirely of the brown tiger prawn and the blue endeavour prawn. The lower tiger prawn catch rates are partly a result of the absence of grooved tiger prawns in the tiger prawn catch of the 'north' stratum.

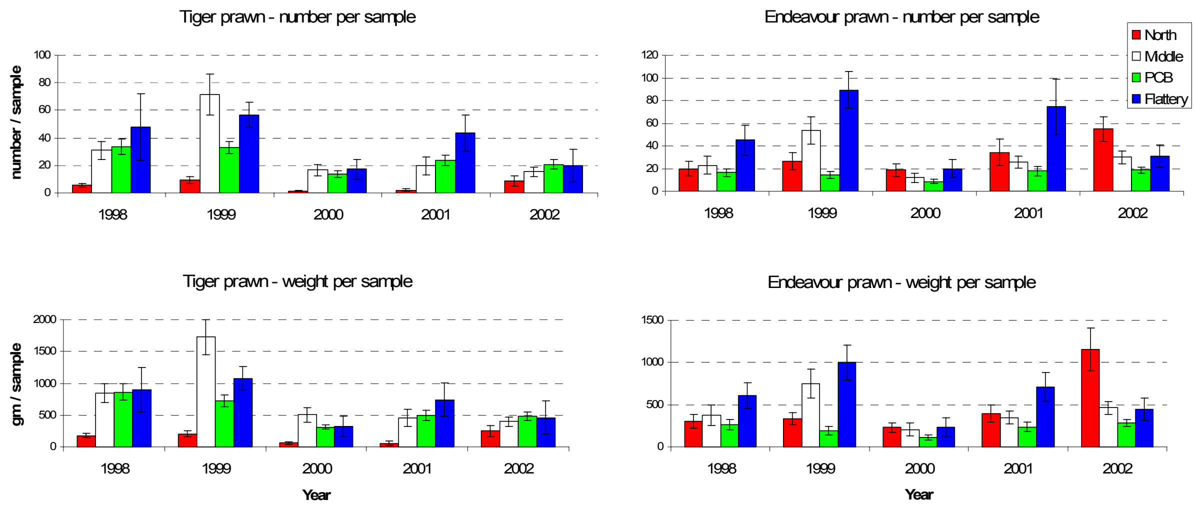

Figure 24 Trends in the northern Queensland east coast survey indices (catch rates) by year and strata compared with the index based on the pooled data from all of the northern Queensland east coast survey sites. The error bars show the 95% confidence intervals of the estimates of abundance.

The stronger tiger and endeavour prawn recruitment in 1999 was most pronounced in the 'Middle' and 'Flattery' strata. For tiger prawns the highest survey index was in the 'Middle' stratum and for endeavour prawns the 'Flattery' stratum. The individual species catch rates (section 5.3) and size distribution analyses (section 5.4.2.2) suggest that the increase in tiger recruitment in 1999 was largely the result of stronger recruitment of the grooved tiger prawn. In contrast to this the individual species data for endeavour prawns (section 5.3) indicates that recruitment of both endeavour prawn species was stronger in 1999.

Summary

Although the north Queensland survey indices for tiger and endeavour prawns mirror the trends in the commercial catch and recruitment indices, based on the commercial data the survey indices are more variable than the fishery indices. This suggests that either the fishery indices are less sensitive to changes in recruitment or the survey indices are over-estimating the variation in recruitment between years.

5.5.2 Torres Strait

Figure 25 compares the Torres Strait survey recruitment indices, based on abundance (numbers) and biomass (weight) with the fishery indices of recruitment (March CPUE and April CPUE). As for figures in section 5.1.2 the data has been plotted on a relative abundance (proportional) scale standardised to the 2001 year.

The Torres Strait survey tiger prawn indices are a good match to the trends in the commercial indices of recruitment (March and April CPUE). All of the indices suggest a high recruitment in 1998 followed by a decline to a low in 2000 and subsequent increase during 2001–02. There are some differences, however, between the survey and commercial indices. The survey indices for 2002 are lower than the commercial indices that may be a result of the delayed timing of the 2002 survey. In comparison with the March fishery index, the survey indices have under-estimated the tiger prawn recruitment in 1999 and 2000. If the data is standardised to 2000, which was the year of lowest tiger prawn recruitment, then the 1998 survey indices are higher than the commercial indices for that year.

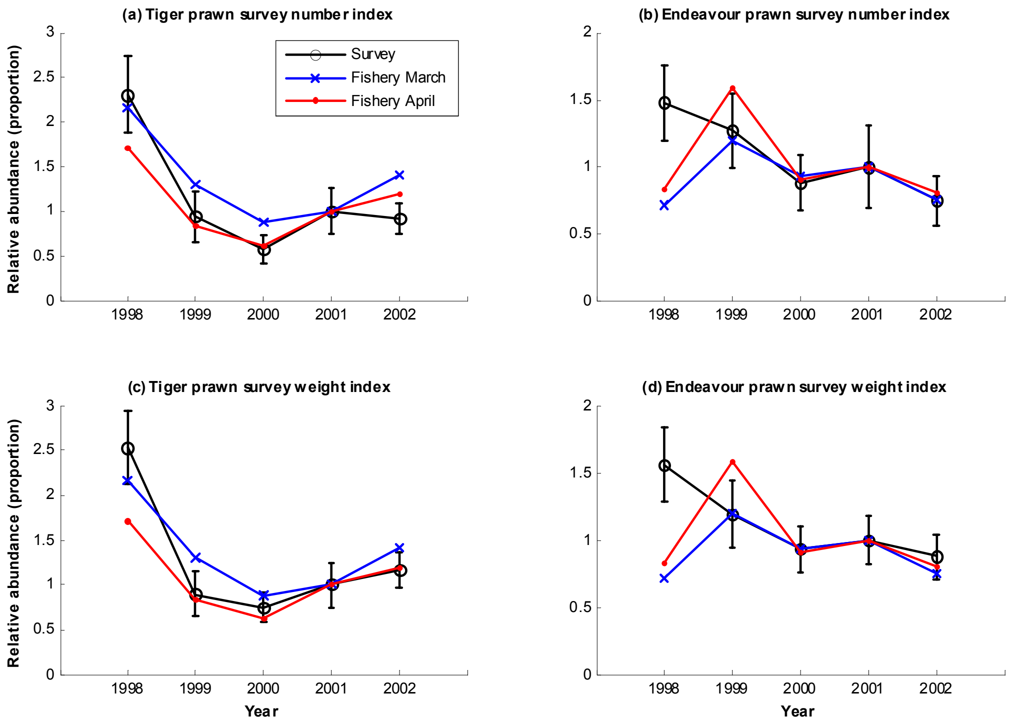

Figure 25 Trends in the Torres Strait tiger prawn and endeavour survey indices compared with the March and April commercial catch rates (CPUE). The error bars represent the 95% confidence interval of the survey estimates.

The endeavour prawn survey indices are a close match to the fishery indices for the years 2000–02. In contrast the survey indices for 1998 are much higher than the fishery indices. Although the 1999 survey indices are close to the March fishery index it is lower than the April fishery index. Therefore the 1999 peak of endeavour prawn recruitment that is obvious in the fishery data has been masked in the survey results. The survey data has over-estimated the 1998 recruitment and under-estimated the 1999 recruitment. A possible explanation is the change in otter boards between the 1998 and 1999 surveys.

Prior to the first survey in 1998 the flat timber otter boards that had been used on the *Gwendoline May* during earlier trawl survey studies were replaced with number five bison boards, which are a hydrodynamic style of board. The new boards caused a number of problems while shooting away the nets during the 1998 survey. Based on the advice of local fishers, who were experienced with this style of otter board, the number five boards were replaced with smaller number three bison boards. These fishers also assisted with the tuning of the boards prior to the second (1999) survey. The same boards and board settings were used on all of the subsequent surveys. Therefore, a possible explanation for the inflated Torres Strait survey recruitment estimates for the first survey is that the larger otter boards increased the swept area of the nets compared with the subsequent surveys.

The 1999 survey was delayed by cyclone 'Rona' so the Torres Strait samples were collected close to the full moon, which may have lowered the survey catch rates for endeavour prawns. In addition, the size distribution data (section 5.4.3.2) indicates that many of the endeavour prawn recruits were small (<20 mm CL). Prawns of this size are only partially retained by the nets, therefore their presence in the samples indicates a much higher abundances of small prawns on the seabed. Further analysis is required to determine whether adjusting for net selectivity when calculating the catch rates can improve the endeavour prawn survey recruitment index.

The delay in the timing of the 2002 survey to early March to avoid a full moon in late February of 2002 appears to have had a slight impact on the survey results. The 2002 survey index based on abundance (numbers) for both tiger and endeavour prawns is slightly lower than the survey index based on the biomass (weight). The delay in the survey timing would have allowed the biomass of prawn stock to increase due to growth, as the abundance decreased due to a combination of natural and fishing mortality. The recommendation arising from this observation is that it is preferable to conduct the surveys during the seasonal closure and if necessary make adjustments to the catch rates to account for variations in moon phase.

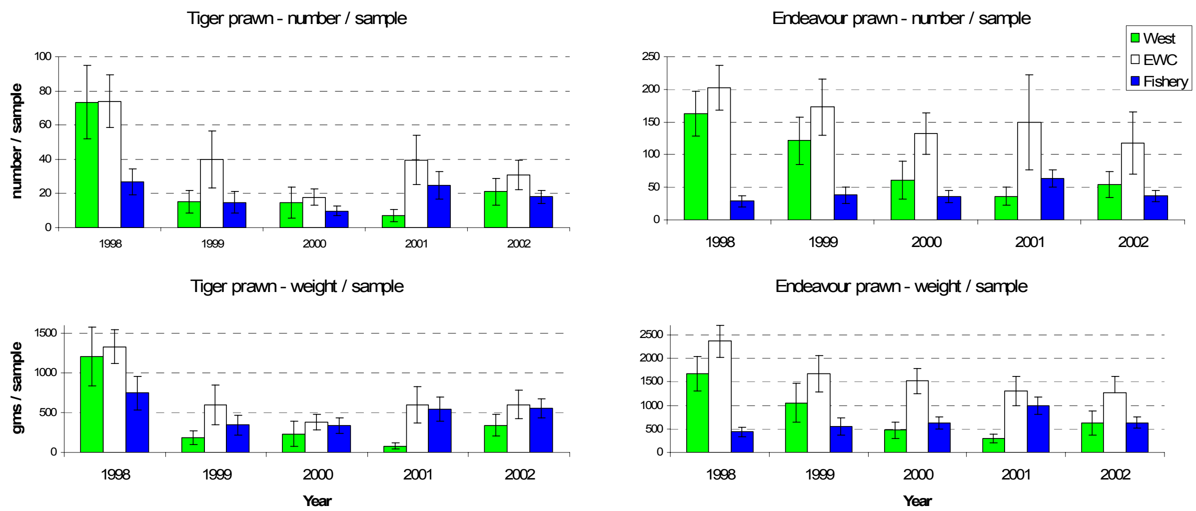

Figure 26 Trends in the Torres Strait survey indices (catch rates) by year and strata compared with the pooled data from all Torres Strait survey sites. The error bars show the 95% confidence intervals of the estimates of abundance.

A comparison of the survey index based on data from each Torres Strait stratum with the index based on all Torres Strait samples (Figure 26) shows that, in general, the three strata show similar trends although there are consistent differences between the strata. The endeavour prawn indices for the 'East of Warrior Reef Closure' (EWC) stratum are all higher than for the other strata, especially the number index for the 2000 to 2002 surveys. This suggests that many of the endeavour prawn recruits were still small and within the East of Warrior closure when the surveys were conducted. Studies that are based on monthly survey data (Turnbull and Watson, 1991) indicate that endeavour prawns migrate from the closed areas into the area open to fishing during March to June. Therefore the survey sites in the 'fishery' stratum may be a poor indicator of endeavour prawn recruitment, as most of the recruits appear to be still in the closed areas when the surveys are conducted during February.

There are also some differences between years. The 2001 indices for both tiger and endeavour prawn were much lower in the 'West of Warrior Reef Closure' (West) compared with the other strata. Similarly, in 1998, the endeavour prawn indices were much lower in the 'fishery' compared with the other strata. The 1998 tiger prawn number index based on the sites within the 'fishery' stratum was low compared with the indices based on the sites in closed areas ('west' and 'EWC') and the weight index for the 'fishery' stratum was relatively higher than the number index due to the larger size of the tiger prawns in the 'fishery' stratum. Therefore the survey results suggest that at the start of the 1998 season in Torres Strait there were high abundances of smaller tiger prawns inside the closures and also a high abundance of larger tiger prawns already in fishable areas. This matches with the fishery data that also indicates that 1998 was a year of higher than average tiger prawn recruitment.

Summary

The Torres Strait survey data provides a fishery-independent recruitment index for tiger prawns that matches with trends in the commercial catch and a fishery based recruitment index (March CPUE). Although the survey index for endeavour prawns is not a good match to the fishery data for the first two surveys, the discrepancy can be explained by a change in the otter boards and a delay in the timing of the 1999 survey. In addition, the size frequency data (section 5.4.3.2) indicates that use of a net selectivity adjustment may improve the reliability of the index by adjusting for the catch rates of individuals that are not fully selected by the nets.

5.6 Indices of spawner biomass

5.6.1 North Queensland

The spatial resolution of the CFISH data, especially for earlier years, is low (30-minute grid level); therefore it was not possible to define areas on the northern Queensland east coast that could be used to estimate a spawning-stock index. In addition, there is little information in the literature on spawning times for this fishery. It was assumed that the main spawning time would be similar to that described for the Torres Strait tiger prawn fishery (September-October). As the 'North' is relatively lightly fished, data from this stratum was not used in the calculation of a spawner biomass index. The spawner index was calculated as the mean tiger prawn catch rate of the daily vessel records that were within the remaining strata (Middle, PCB and Flattery) for the months of September and October.

The use of alternative months during August to November to generate the spawner index was investigated. The results show that the months of September and October produce a virtually identical spawner index, whereas the months of August and November deviate from the September-October spawner index in some years. This observation supports the use of the September-October period as the spawner index for this fishery.

In Figure 27 the recruitment index (numbers/sample) for each survey (1998–02) was plotted against the spawner index for the preceding September-October (1997–01) as relative indices standardised to the 2000 year for spawner index and 2001 for the recruitment index. As a comparison, the fishery-based recruitment index (March CPUE) was similarly plotted against the spawner index.

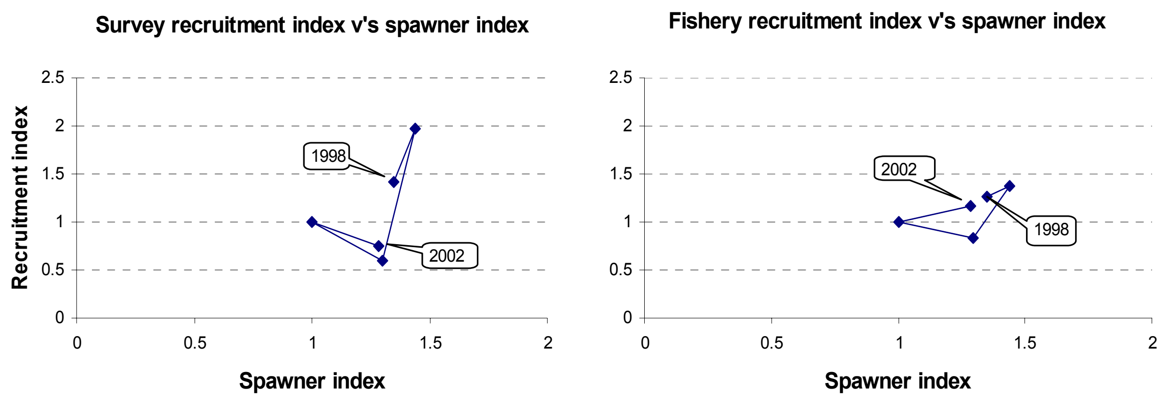

Figure 27 Relative indices of recruitment indices plotted against the North Queensland spawner biomass index. The indices have been standardised to 2001.

Although the plots using the survey and fishery-based recruitment indices are similar, the variation in the survey recruitment index is large when compared with the fishery recruitment index. This suggests that the either survey recruitment index has over-estimated the variation in recruitment or, conversely, the fishery recruitment index has under-estimated the changes in recruitment. A comparison of the variation in the fishery recruitment indices for North Queensland (Figure 27) with Torres Strait (Figure 28) shows that North Queensland fishery recruitment indices show a much smaller relative variation between years. The true changes in annual recruitment may well lie between those suggested by the survey and fishery based indices.

The spawner biomass index was highest in September-October of 1998 which has produced a slightly higher than average recruitment in 1999. This contrasts with Torres Strait where a slightly higher than average spawner biomass in September-October of 1997 produced an exceptionally high recruitment in 1998. The 2002 survey index is lower than the fishery index which is possibly a result of the delayed timing of the 2002 survey.

5.6.2 Torres Strait

The spatial resolution of the Torres Strait logbook data is at the six-minute grid level; therefore, it was possible to define six-minute grids that could be used to estimate a spawner index. Based on the results in Blyth et al. (1990) the grids from Warrior Reef to the east of Yorke Islands were selected to define the main spawning area and the months of September and October selected to define the spawning period. Although spawning also occurs to the west of Warrior Reef this area cannot be included in an index based on commercial data as the area is permanently closed to trawling. The spawner index was calculated as the mean tiger prawn catch rate of the daily vessel records from within the chosen area (grids) of the fishery and time period (months).

As for North Queensland the use of alternative months during August to November to generate the spawner index was investigated. Although using the individual months of August to November results in a set of spawner indices that have the same general trend, that August-September data indicates a higher spawner biomass in 1998 than 1997. In contrast, the October-November data indicates a higher spawner biomass in 1997. Statical analysis of the 1986–91 monthly survey data indicates that October has the highest average tiger prawn fecundity index during the months of June to December. It was considered, however, that using only October may be too restrictive and the inclusion of September averages over the discrepancy between months for 1998. The use of a wider area of the fishery to estimate the spawner index was also investigated and found to produce similar results to the smaller set of grids.

In Figure 28, the recruitment index (numbers/sample) for each survey (1998–02) was plotted against the spawner index for the preceding September-October (1997–01) as relative indices standardised to the 2000 year for spawner index and 2001 for the recruitment index. As a comparison, the fishery-based recruitment index (March CPUE) was similarly plotted against the spawner index.

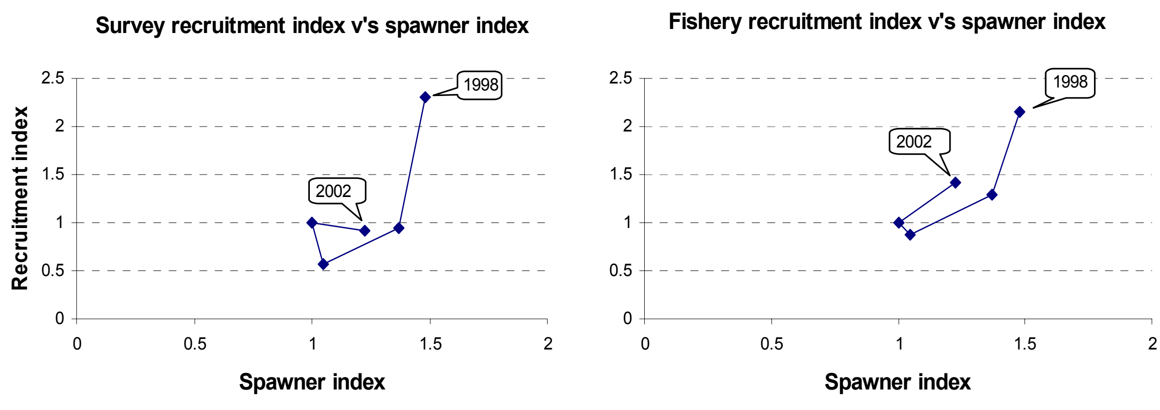

Figure 28 Relative indices of recruitment indices plotted against the Torres Strait spawner biomass index. The indices have been standardised to 2001.

The plots using the survey and fishery-based recruitment indices are similar (Figure 28). Both indicate that the 1998 tiger prawn recruitment was higher than would be expected from the spawner biomass in the preceding September-October. As for North Queensland, the 2002 survey index is lower than the fishery index. This is possibly a result of the delayed timing of the 2002 survey under-estimating recruitment.

6 Discussion

The analysis of the survey data and comparison of the results with the trends in the commercial data show that the recruitment surveys are building up a time-series of fishery-independent data that can reliably be used to enhance the analysis of the commercial fishery data for the Torres Strait and North Queensland east coast prawn trawl fisheries. The annual surveys cover a large geographic range at relatively low cost, and for this reason they provide a cost effective method of obtaining fishery-independent data for the Torres Strait and North Queensland east coast prawn trawl fisheries.

The survey size data provides information on the size structure of the stocks of each species at the start of the fishing season. This size structure can be related to the age structure using the published growth rate parameters. The size frequency data indicates that recruitment to the fishery at the start of the season consists of a range of monthly size (age) cohorts that were produced during the extended spawning period of August to November. The size frequency also allows estimation of the weights of each species and gender in the samples. The survey catch rates can then be compared with commercial catch rates after adjustments are made to convert the data to the equivalent catch per night. The commercial catches are recorded as weight of catch per night of trawling.

The recruitment indices generated from the survey data generally match with trends in the commercial harvest data especially for tiger prawns. Although the survey recruitment indices are more variable, between years, than the fishery based indices (March CPUE) they provide a useful comparison with the fishery-based indices. The Torres Strait survey data has been used to validate the trends observed in the fishery data as part of a refinement of the Torres Strait tiger prawn stock assessment (O'Neill and Turnbull, 2005).

The survey data complements the commercial harvest data and will assist with the development of species-based stock models for the northern Queensland east coast tiger prawn fishery. The species composition information, which is presented on the CD at the back of this document, provides information on the species composition of the commercial prawn stocks at the start of the season. The development of species-based stock models for the North Queensland fishery requires information that can be used to partition the commercial catch data into individual species. The surveys are providing data that could assist with this process by indicating the composition of the stocks at the start of the season along different sections (strata) of the coastline. Since 2001, the collection of bycatch information has also been very cost effectively 'piggy-backed' onto the recruitment surveys. Preliminary analysis of the bycatch data is provided on the CD.

This study provides an initial examination of the stock recruitment data for the North Queensland and Torres Strait fisheries that is based on a fishery-independent estimate of recruitment. Although the results are preliminary — due to the small number of data points — they provide a useful comparison with stock recruitment data obtained entirely from the commercial harvest data. There are concerns with using only the commercial data to estimate the recruitment and spawner indices as changes in the fishing power of the fleet effects the daily vessel catch rates on which these indices are based.

Further work is required to improve the process of analysing the survey data and estimating recruitment indices. A General Linear Modelling approach to the analysis of the survey data was adopted by O'Neill and Turnbull as a component of updating the tiger prawn stock assessment for the Torres Strait (O'Neill and Turnbull, 2005). A similar approach is also being applied to the survey data for the north Queensland east coast. These studies, which are utilising the data from the surveys, will improve the analysis of the data by applying a statistical approach to the analysis and standardisation of the raw survey data.

The recruitment surveys should be continued as they are providing useful time-series of fishery-independent data that complements the analysis of the commercial fishery data. The recruitment indices generated from the survey data generally match with trends in the commercial harvest data especially for tiger prawns that are considered more susceptible to overfishing. The survey data can assist with the development of species-based stock models for the northern Queensland east coast tiger prawn fishery. The survey recruitment indices and the information on size structure of the stocks at the start of each fishing season provide a fishery-independent assessment of the status of the commercial prawn stocks at a species level.

7 Conclusions

The results presented in this report include the data from the 2001 and 2000 LTMP surveys that were conducted by DPI&F. This has enhanced the value of the final report by providing a longer time-series of data. The results show that fishery-independent recruitment surveys are a robust and cost effective tool for providing the data needed to monitor prawn stocks, especially in multi-species fisheries such as the northern Queensland east coast tiger prawn fishery. The recruitment indices provided by the surveys compared well with trends in the commercial harvest data, especially for tiger prawns that are considered more susceptible to overfishing. The survey data complements the commercial harvest data and will assist with the development of species-based stock models for the northern Queensland east coast tiger prawn fishery. The survey recruitment indices and the information on size structure of the stocks at the start of each fishing season provide a fishery-independent assessment of the status of the commercial prawn stocks at a species level.

8 Benefits

The key objective of this study was to develop and test a robust and cost effective prawn recruitment survey methodology that could be adopted by the Department of Primary Industries and Fisheries (DPI&F) to monitor the status of the tiger and endeavour prawn stocks that are harvested in the northern Queensland east coast and Torres Strait prawn fisheries. The survey methodology was developed and tested during the 1998 to 2000 surveys. In 2001, DPI&F incorporated the survey methodology into the Long Term Fisheries Monitoring Program (LTMP) that had been in operation for two years. The LTMP prawn recruitment surveys provide standardised catch rates of prawn abundance (numbers) and biomass (weight) by species at the start of the season. These catch rates provide a relative annual index of recruitment for the main tiger and endeavour prawn species. In addition, information is obtained on the size distribution of the main commercial prawn species that recruit into the fishery at the start of each fishing season. The data collected by the annual recruitment surveys has been used in recent stock assessments for tiger prawns in Torres Strait and along the northern Queensland east coast as a fishery-independent check on trends in the status of the stocks.

Data from the surveys conducted by the project were used to provide scientific advice to industry and managers in 1999–2000 via the Torres Strait Prawn Working Group and an article in the Torres Prawn Handbook 2000. The surveys also provide an opportunity to collect data on the bycatch associated with prawn trawl fisheries and for the collection of samples for genetics studies. The 2001 survey provided bycatch samples from the area between Cape Flattery and Torres Strait for FRDC Project 2000/170. The northern and southern LTMP surveys were used to collect bycatch samples for the LTMP and a CRC Reef project. The 2004 survey provided samples of brown tiger prawns for a project investigating the genetic population structure survey of the brown tiger prawn. The 2004 survey also provided scallop samples for a project investigating the genetics of the Queensland scallop species.

In 1999, data from the FRDC recruitment surveys was used to address questions raised about the value of continuing the East of Warrior Closure in Torres Strait. The east of Warrior Reef area is closed to trawling for eight months of the year and has been only lightly trawled since 1991. Prior to the closure this area was heavily trawled at the start of each season. At the December 1999 meeting of the Torres Strait Prawn Entitlement Holders several industry members questioned the value of continuing the East of Warrior Closure. Their arguments were based on a common belief of fishers that if trawl grounds are not regularly ‘worked’ the grounds become less productive in terms of prawn catches. Data from sites within the East of Warrior Closure for 1998 and 1999 were compared with data from the same area in 1991. The comparison indicates that within the closure area catch rates have not decreased and have possibly increased. More detailed information on this issue is available in the 2000 edition of the Torres Strait Prawn Handbook.

9 Further Development

Further investigation of the recruitment indices using a General Linear Modelling approach has occurred as a component of the tiger prawn stock assessment process (O'Neill and Turnbull, 2005). A similar approach is also being applied to the survey data for the northern Queensland east coast. Further detailed comparison of survey data with the commercial fishery data will continue as a component of the Long Term Fisheries Monitoring Program and the results will be reported in the bi-annual updates of the LTMP report on the Northern Queensland east coast trawl fishery surveys (Turnbull et al. 2004).

10 Planned Outcomes

DFI&F has continued and expanded the annual surveys developed by the project as a component of the Fisheries Long Term Monitoring Program (LTMP). This was the main intent of the project and the reason for developing and testing the recruitment survey methodology.

11 References

Blyth, P.J., Watson, R.A. and Sterling, D.J. (1990). Spawning, recruitment and life history studies of *Penaeus esculentus* (Haswell, 1879) in Torres Strait. In: Torres Strait prawn project: a review of research 1986–1988. (Ed. J.E. Mellors). Qld Dept Primary Industries Information Series, Qld Dept of Primary Industries, Brisbane, Australia, QI90018. pp.38–50.

Derbyshire, K.J., Helmke, S.A. and Bennett, R.E. (1992). Stock assessment in the north-east Australian prawn trawl fishery. *Final report to the Fishing Research and Development Corporation (FRDC)*. Department of Primary Industries, Queensland Government (QDPI). June 1992.

Derbyshire, K.J., Willoughby, S.R., McColl, A.L. and Hocroft, D.M. (1995). Small prawn habitat and recruitment study. *Final report to the Fishing Research and Development Corporation (FRDC)*. Department of Primary Industries, Queensland Government (QDPI). June 1995.

Hyland, S.J. (2003). Coastal Fisheries Resource Monitoring in the Great Barrier Reef World Heritage Area: Technical Report on Activities from June 2000 to March 2003. Unpublished report to CRC Reef. 83pp.

Kung, J.P., Turnbull, C.T., Murphy, R., Taylor, S. and Marrington, J. (2005). *Torres Prawn Handbook 2005*. Australian Fisheries Management Authority. Canberra, Australia.

McLoughlin, K. (2002) Northern Prawn Fishery, pp.63–71. In: Acton, A. (ed.) (2002). Fishery Status Reports 2000–2001: *Resource Assessments of Australian Commonwealth Fisheries.* Bureau of Rural Sciences, Canberra.

O'Neill, M.F. and Turnbull, C.T. (2005). Stock Assessment of the Torres Strait Tiger Prawn Fishery (*Penaeus esculentus*). Draft.

Penn, J.W., Caputi, N. and Hall, N.G. (1995). Spawner-recruit relationships for the tiger prawn (*Penaeus esculentus*) stocks in Western Australia. ICES Marine Science Symposia (Actes du symposium). 199: 320–333.

Sterling, D.J., Mellors J.E. and Watson, R.A. (1990). Trawl gear performance trails. In Torres Strait prawn project: a review of research 1986–1988. (Ed. J.E. Mellors). Qld Dept Primary Industries Information Series, Qld Dept of Primary Industries, Brisbane, Australia, QI90018. pp.38–50.

Turnbull, C.T. and Gribble, N. (2003). Current Assessment of the northern Queensland Tiger and Endeavour prawn stocks. QDPI Information Series Publication QI03014.

Turnbull, C., Mellors, J. and Atfield, J. (2004). Fisheries Long Term Monitoring Program: A summary of Tiger and Endeavour Prawn Survey Results: 1998–2002. Department of Primary Industries and Fisheries, Queensland.

Turnbull, C.T. and Watson, R.A. (1991). The effect of the 1990–91 seasonal and strip closures on catches in the Torres Strait Prawn Fishery. QDPI report to the Torres Strait Prawn Working Group. QI90018. pp.29–37.

Turnbull, C.T. (1991). A review of the Queensland Department of Primary Industries' research on commercial prawn species in Torres Strait. In: Proceedings of the Torres Strait Baseline Study Conference. (Eds. D. Lawrence and T. Cansfield-Smith) Great Barrier Reef Marine Park Authority, Townsville, Australia.

Watson, R.A. and Turnbull, C.T. (1993). Migration and growth of two tropical penaeid shrimps within Torres Strait, northern Australia. Fisheries Research, 17: 353–368.

Watson, R.A. and Mellors, J.E. (1990). General Introduction. In: Torres Strait prawn project: a review of research 1986–1988. (Ed. J.E. Mellors). Qld Dept Primary Industries Information Series, Qld Dept of Primary Industries, Brisbane, Australia, QI90018. pp.3–9.

Williams, L.W. (2002) Queensland's fisheries resources. Current condition and recent trends 1988–2000. QI02012. Queensland Government, Department of Primary Industries, Brisbane. 180p.

Acknowledgments

The crew of the DPI&F research vessel *Gwendoline May* — Colin Cant, Glen Chisholm and Paul Leeson — are acknowledged for their assistance with the implementation of the recruitment surveys. Commercial fishers Barry Ehrke and Bruce Rose assisted with the tuning of the research trawl gear and provided advice on trawl site locations. Scott Foster, a DPI&F biometrician, provided advice on GenStat procedures that could be used to transform and analyse the survey catch rate data. He also wrote the programs that were used to analyse the length-weight data. The Fisheries Research and Development Corporation funded this study. The DPI&F Long Term Fisheries Monitoring Program funded the 2001 and 2002 surveys, which were included in the analysis presented in this FRDC Final Report.

Appendix: 1 Intellectual Property

There are no intellectual property issue pertaining to the project. The data collected during the FRDC funded surveys is stored both on the Cairns Northern Fisheries Centre server and in the LTMP database, which is on the main server in the Primary Industries Building, Brisbane.

Appendix: 2 Staff

Staff	Position/Role	Funding	Time
Clive Turnbull	Senior Fisheries Biologist, Principal Investigator	DPI&F	60%
Celeste Shootingstar	Fisheries Technician, assisting with fieldwork, sample processing, data entry and analysis.	FRDC	50%

Appendix: 3 Fisheries Long Term Monitoring Program. A summary of Tiger and Endeavour Prawn Survey Results: 1998–2002

The CD attached to the inside of the back cover of this document contains an electronic version of this report and a copy of the associated LTMP report:

Turnbull, C., Mellors, J. and Atfield, J. (2004). Fisheries Long Term Monitoring Program: A summary of Tiger and Endeavour Prawn Survey Results: 1998–2002. Department of Primary Industries and Fisheries, Queensland.

Electronic copies of the LTMP report can also be downloaded from the DPI&F website at:

http://www.dpi.qld.gov.au/fisheriesmonitoringprogram/17743.html

The LTMP report contains a general analysis of the species composition, size frequency distribution and catch rates of the survey data. As the LTMP and FRDC reports were written concurrently, it was considered more appropriate to include the LTMP prawn report as an appendix rather than duplicating results in this report. The LTMP report contains a general analysis of the data for all five northern surveys and also includes the southern survey (Cairns to Townsville) that was conducted in 2002. The LTMP report will be updated biannually to incorporate the additional years of survey data. Unfortunately, the 2003 survey was cancelled due to an engine failure on the research vessel. The 2004 and 2005 surveys were, however, successfully completed and the results will be included in the 2006 update of the LTMP report.

Information Series
ISBN 0 7345 0298 2
ISSN 0727 6281
QO04015